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NOUVELLE SÉRIE

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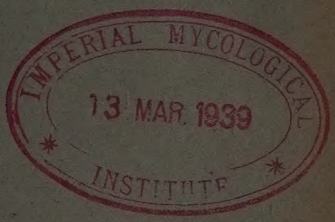

VOLUME XXI

№ 7

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PHYSICS

SPATIAL DISTRIBUTION OF VISIBLE RADIATION PRODUCED BY FAST ELECTRONS

By P. A. CHERENKOV

(Communicated by S. I. Wawilow, Member of the Academy, 27. X. 1938)

According to Tamm and Frank's theory(1) angle θ, determining the direction of the radiation produced by electrons, which move in a medium with a velocity exceeding that of light in the same medium, ought to satisfy the relation

$$\cos\theta = \frac{1}{\beta n} \qquad (1)$$

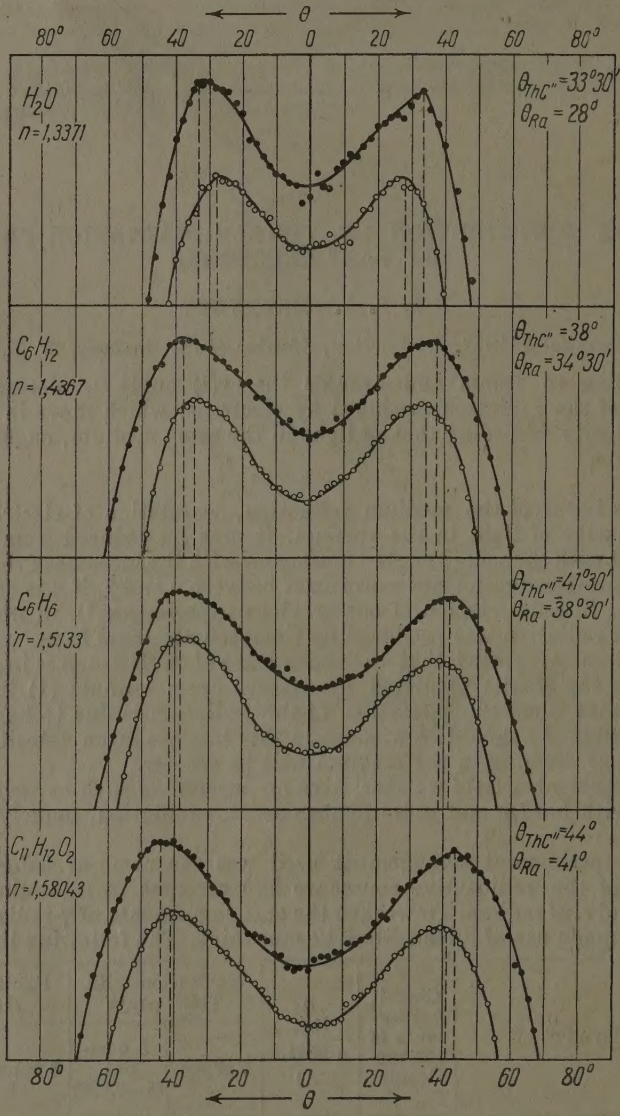
where n is index of the medium refraction, β—relation of electron velocity to the velocity of light in the vacuum. It may be deduced from this correlation that with the same β angle θ must grow with the increase of the refraction index. A similar dependence must exist between θ and β, if n is constant and β variable. In a description of our previous experiments(2), in which excitation of the radiation was produced by Compton electrons from γ-rays of Ra, we have already reported that the dependence of angle θ on n is in good agreement with the results predicted by theory. From formula (1) it should be expected that when the excitation of the radiation is due to harder γ-rays, the magnitude of θ should grow, since in this case the mean velocity of Compton electrons forming in the medium will be greater.

In the present article we shall give an account of such experiments, carried out with harder and more homogeneous γ-radiation, namely the ThC'' radiation.

The experimental arrangement used was the same as before(2,3). The intensity of the radioactive source we had recourse to (radiothorium) was 140 mg-equiv. of radium. To weaken the soft components of γ-radiation of the source we made use of a lead filter 12 mm thick. The following liquids were

Liquid	Chemical formula of the molecule	n (λ = 4861.5 Å)	Excitation with ThC'' γ-rays		Excitation with Ra γ-rays	
			θ exper.	θ comput. (β=0.896)	θ exper.	θ comput. (β=0.847)
Water	H_2O	1.3371	33°30′	33°30′	28°	28°
Cyclohexane	C_6H_{12}	1.4367	38°	39°	34°30′	34°40′
Benzene	C_6H_6	1.5133	41°30′	41°35′	38°30′	38°40′
Ethyl cinnamate	$C_{11}H_{12}O_2$	1.58043	44°	45°10′	41°	41°50′

used for investigation: water (n=1.3371), cyclohexane (n=1.4367), benzene (n=1.5133) and ethyl cinnamate (n=1.58043). Microphotometrical curves of the photographs obtained are given in the figure (upper curve). Upon each of these curves one may see two well expressed maximums, corresponding to the directions of the maximum radiation intensity. The angular distance between



the maximums of intensity grows with the increase of the refraction index of the liquid.

The numerical values of the angles θ between the direction of the beam of ThC'' γ-rays and that in which the intensity maximum is observed, for each investigated liquid are given in the table (column four).

For water the maximum radiation is observed at an angle $\theta = 33°30'$. On the basis of formula (1) the effective β, corresponding to this angle, should be equal to 0.896*. One may assume with a sufficient approximation that the effective value β of Compton electrons formed by γ-rays of ThC'' will for other liquids be also equal to 0.896. If so, the theoretically expected angles θ for these liquids should have values given in column 5 of the table. These values fully agree with the magnitudes of angles found experimentally.

In the above table (columns 6 and 7), as well as in figure (lower curves), for sake of comparison are given the results of analogous experiments, in which the radiation of the liquids was excited by γ-rays of Ra. These experiments have already been made for most of the liquids under consideration[2]. In spite of this fact, they have been repeated by us under the same, somewhat better geometrical conditions, similar to those prevailing in our experiments with γ-radiation of ThC''. From the comparison of columns 4 and 6 of the table it may be seen that when for excitation of the radiation use is made of γ-rays of ThC'', in all the liquids under investigation maximums of intensity are, according to expectation, observed at angles somewhat larger than those observed when radiation in produced by γ-rays of radium.

The experiments described above thus show that the dependence of angle θ on n and β observed by us fairly agrees with Frank and Tamm's theory.

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2. XI. 1938.

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* It should be noted that the value of the effective β found this way does not determine the mean energy of Compton electrons. It follows from the nature of the effect of Compton scattering of γ-rays that even in the case of the ray-beam being absolutely monochromatic and parallel, those conditions will not be present for recoil electrons. The latter will suffer scattering when passing through the medium. Moreover, the radiation of each separate electron is characterized by a different value of β, since the electron loses its volocity while moving in a medium. The effective velocity of recoil electrons will therefore be in general smaller than their mean velocity.

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PHYSIQUE

LA POLARISATION DE LA LIGNE VERTE DE LA LUMINESCENCE DU CIEL NOCTURNE

Par I. A. KHVOSTIKOV

(Présenté par S. I. Wawilow, de l'Académie, le 7.X.1938)

1. Ligne la plus intense du spectre du ciel nocturne est la ligne verte $\lambda = 5577.3$ Å. Cette ligne fait partie du spectre de l'oxygène atomique. La radiation apparaît lors du passage de l'atome de l'état métastable $^1S_0$ en un autre état métastable $^1D_0$. Jusqu'à présent on considérait comme évident que la ligne verte du ciel nocturne n'est pas polarisée. Cela résultait de la théorie photo-chimique de Chapman, ainsi que de la théorie, d'après laquelle l'action des électrons secondaires d'origine solaire sur le gaz est la cause commune de radiation de l'atmosphère (cette dernière théorie est soutenue par l'école française des géophysiciens). Par contre, les expériences, que je viens d'achever, ont montré que la ligne verte est polarisée, le degré de polarisation étant assez haut, voisin de 12%. Les mesures ont été effectuées par plusieurs méthodes indépendantes, et ont toutes donné des résultats concordants.

2. Une petite intensité de la ligne verte est la difficulté essentielle des observations de sa polarisation. Pour séparer la ligne verte des autres composantes du spectre de luminescence du ciel nocturne, on se sert généralement, dans le cas des observations visuelles, de l'écran de Rayleigh[1]. Si l'on regarde à travers cet écran le ciel dans un nicol, l'oeil étant adapté à l'obscurité, même si l'on voyait le ciel, sa vivacité serait si faible qu'il n'y aurait aucun moyen d'effectuer les mesures. Le nicol, ainsi que d'autres prismes polarisants semblables, affaiblient un rayon non polarisé plus de deux fois.

Une combinaison heureuse d'écrans, trouvée par moi, a permis de séparer une région très restreinte du spectre (5500—5700 Å), la ligne verte étant très peu affaiblie. D'autre part, j'ai mesuré la transparence, pour les rayons verts, des 14 différents prismes polarisants, dont il a été choisi un avec une parfaite transparence (un prisme de Franck-Ritter, confectionné par l'Institut Optique à Léningrad).

Ayant eu à notre disposition de tels écrans et prismes, nous avons pu commencer les expériences quantitatives de la polarisation. Afin d'effectuer les mesures pour des intensités aussi petites, on pouvait utiliser la méthode de «limite de vision» de Wawilow[2], qui trouve aujourd'hui beaucoup d'applications.

Les premières observations approximatives ont été effectuées d'après le schéma le plus simple (fig. 1). Le prisme polarisant était monté de façon que son axe de symétrie, même pendant la rotation du prisme, coïncide avec l'axe optique de l'appareil.

On se servait d'un coin photographique gris-neutre K pour affaiblir la lumière jusqu'à la limite de vision. Un long tuyau Létait destiné à limiter le champ visuel, qui doit être petit pour qu'il n'y ait pas d'étoiles d'une

vivacité marquante. Les observations ont été effectuées avec un oculaire O. La combinaison d'écrans F séparait la ligne verte.

Par la méthode de «limite de vision» on faisait des mesures de l'intensité pour deux positions mutuellement perpendiculaires du prisme polarisant. Les mesures préliminaires ont établi que l'intensité de la lumière non polarisée ne varie pas lorsqu'on fait tourner le prisme polarisant P. Par conséquent, l'inégalité des intensités de la ligne verte pour deux positions quelconques mutuellement perpendiculaires du prisme polarisant prouvait la présence de la polarisation.

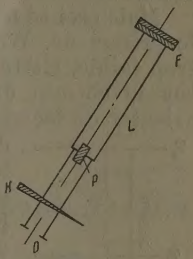

Fig. 1.

Les premières observations effectuées pendant la nouvelle lune, en juillet de cette année, ont montré qu'à minuit, dans la région de l'étoile Polaire, la composante horizontale du vecteur lumière est plus grande que la seconde composante qui lui est perpendiculaire. Le résultat moyen des mesures donnait pour les relations des intensités de ces composantes $\frac{I_h}{I_v} = 1.25$.

3. Quoique toutes les précautions pour que le prisme polarisant soit bien centré suivant l'axe optique aient été prises, il restait toutefois un certain risque, que l'effet trouvé ne serait qu'apparent, étant dû à la rotation d'une des parties de l'appareil relativement aux autres. J'ai essayé de «voir» la polarisation directement, en me servant du prisme de Wollaston, c'est-à-dire en essayant d'obtenir de la manière ordinaire les deux moitiés adjacentes du champ visuel, dont la lumière est polarisée dans les directions mutuellement perpendiculaires. Pour un montage exact de l'appareil, l'inégalité des vivacités des deux moitiés du champ visuel indiquerait la présence de la polarisation. Or, il est impossible de distinguer la différence de vivacité pour les intensités aussi petites par le procédé habituel. Mais en recourant de nouveau à la limite de vision de l'oeil adapté à l'obscurité, on peut distinguer la différence des vivacités des deux moitiés par le fait que les moitiés disparaissent pour les positions différentes du coin. Il faut exclure d'abord l'influence possible du coin dans le sens suivant: les deux moitiés du champ visuel peuvent paraître avoir des vivacités différentes, car la partie du coin, où, pour une position donnée, la limière traverse le coin, peut avoir certaine largeur, et par suite les parties différentes du faisceau de rayons passeront par régions du coin à la transparence différente.

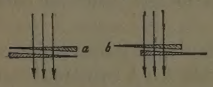

Fig. 2.

Pour cela j'ai utilisé deux coins, absolument identiques, avec une petite constante, superposés par des bouts contraires (fig. 2,*a*). Il est évident que dans ce cas la transparence du coin est partout la même, et pour mesurer la transparence il suffit d'écarter les coins l'un par rapport à l'autre (fig. 2, *b*).

Pour vérifier le fonctionnement de l'appareil, nous avons effectué les mesures de la lumière que nous savions d'avance de n'être pas polarisée. Pour cela après chaque observation de la ligne verte on remplacait les écrans, qui séparent cette ligne verte, par une plaque en verre laiteux. L'appareil restait dirigé vers le ciel. On sait que le verre laiteux dépolarise totalement la lumière. Les observations que j'ai produites avec cet appareil pendant la nouvelle lune en août de cette année ont de nouveau montré que la ligne verte est polarisée. Dans la région de l'étoile Polaire, vers minuit, la composante horizontale était, comme auparavant, plus vive que la seconde composante qui lui est perpendiculaire.

Il était désirable de mesurer le degré de polarisation au moyen de cet appareil. Il fallait pour cela affaiblir d'une manière quelconque l'une des

composantes par rapport à l'autre afin d'obtenir l'égalité: le degré d'affaiblissement donnerait alors directement $\frac{I_h}{I_v}$. Il serait naturel d'utiliser à cette fin un prisme polarisant, en tournant lequel on pourrait affaiblir dans la mesure voulue la vivacité de l'une des moitiés par rapport à l'autre.

Mais ceci se montra impraticable puisque la lumière, ayant déjà traversé le prisme de Wollaston, après le passage du prisme polarisant devenait trop faible. Cette difficulté fut évitée de la manière suivante: si l'on pose sur le chemin du rayon une plaque de verre ordinaire, qui se laisse orienter de façon qu'une des composantes de la lumière polarisée soit située dans le plan d'incidence, tandis que l'autre se trouve dans le plan qui lui est perpendiculaire, grâce à la réflexion inégale des deux composantes on réussit d'égaliser pour une position donnée de la plaque les grandeurs des deux composantes. On arrive à avoir la même vivacité pour les deux moitiés du champ visuel, les pertes de la lumière étant besucoup plus petites que quand on a recours au prisme polarisant. L'angle formé par la plaque et le rayon permet de juger directement du degré de la polarisation. J'ai utilisé pour les expériences définitives une colonne de trois plaques. Les mesures éffectuées par la méthode décrite ont donné $\frac{I_h}{I_v} = 1.23$ pour le minuit, dans la région de l'étoile Polaire.

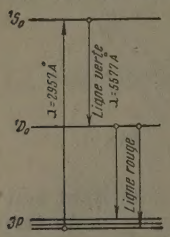

Fig. 3.

4. Pour se procurer la certitude des résultats, il fallait de plus éliminer l'influence possible de l'élément subjectif; à cette fin plusieurs séries d'expériences ont été produites avec l'aide de deux observateurs bien entraînés en mesures par la méthode de «limite de vision». Pour la plus grande objectivité ces observateurs n'ont pas été informés d'avance de la destination des mesures en question.

Les mesures ont été faites par la méthode de rotation du prisme polarisant (la seconde méthode exige une habitude toute spéciale de l'application de la méthode de «limite de vision» simultanément à deux moitiés du champ de vision). Le schéma décrit dans le paragraphe 2 n'a été que légèrement modifié, grâce à quoi les observateurs pouvaient occuper les positions moins fatiguantes. Les observations ont été effectuées par les collaborateurs de l'Institut de Géophysique Théorique de l'Académie des Sciences N. D. Ershova et I. M. Mikhailine pendant la nouvelle lune de septembre. Les résultats des mesures concordent entièrement avec les résultats donnés plus haut.

L'ensemble des mesures donne pour degré de polarisation de la ligne verte la valeur $11 \pm 3\%$. Ces résultats correspondent à la région du ciel aux environs de l'étoile Polaire (la plus grande partie des mesures a été faite entre 11 et 1 heure de matin).

5. La polarisation découverte de la ligne verte doit être étudiée dans l'avenir d'une manière plus détaillée, qu'il n'était possible de le faire jusqu'à présent. Il est nécessaire de répondre à deux questions fondamentales: quelle est la direction de la polarisation aux heures différentes de la nuit, et le degré de polarisation reste-t-il constant ou bien change-t-il pendant la nuit.

Institut de Géophysique Théorique.
Académie des Sciences de l'URSS.

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PHYSICS

ON THE FLUORESCENCE AND ABSORPTION OF PRASEODYMIUM SALT SOLUTIONS

By J. LARIONOV, O. V. NOVIKOVA-MINASH and A. SEIDEL

(Communicated by D. S. Rojdestvensky, Member of the Academy, 26.X.1938)

It is known that solutions of rare earths salts possess besides discrete absorption bands also regions of continuous absorption. For the majority of the rare earths, this continuum begins at 2800—2900 Å and stretches far into the region of short waves. However, according to Prandtl and Scheiner's data(1), the solutions of praseodymium and ytterbium salts seem to form an exclusion from this rule: no continuous absorption was detected by these authors within the region 9300—2200 A they have investigated. This was called in question by Mukherji(2), who affirmed to have detected a number of discrete bands in the region of 2560 Å in absorption spectrum of praseodymium solutions. However, Lange(3) has shown recently that these bands belong to cerium, that was present in Mukherji's preparation as an admixture. Lange did not succeed in detecting any proper absorption of praseodymium down to 44 000 cm^{-1}.

In order to clear up this problem definitively, we have undertaken a detailed investigation of the absorption of praseodymium solutions in the ultraviolet. We have employed the usual procedure. A hydrogen tube was used as the source of light. Photographs of the spectra were taken on a Zeiss quartz spectrograph wth an average dispersion 20 Å/mm in this region. Photographic plates sensitized by sodium salicylate and special Schumann's plates were employed. In order to get rid of any possible organic impurities, the salts were heated at 500—600°C and then dissolved in water, distilled twice over potassium permanganate. The length of the absorbing column varied between 2 and 5 cm.

Since the purest preparations of rare earths usually contain slight admixtures of a series of other elements of this group, the investigation had to be accompanied by a careful control of the degree of purity of the preparations used. Particular danger for our investigation was hidden in a possible admixture of cerium that possesses very intense absorption bands in the ultraviolet. These bands, if superposed on praseodymium absorption, would completely distort the results. This, according to Lange, has taken place in Mukherji's experiments. It was essential, therefore, to make use of a preparation as free from cerium as possible. The purity of the preparations was checked with the aid of the fluorescence method, worked out by us together with Filippov(4). This method secures a very high sensitivity in the case of Ce.

To make analysis for Ce we photographed on the same plate under strictly identical conditions the fluorescence spectrum of a 0.2% solution of praseodymium sulphate and the fluorescence spectra of a series of standard solutions of cerium-3-sulphate beginning with 10^{-3}% and ending with 10^{-7}%

of Ce. In all cases the fluorescence was excited by the optimal source of excitation for small concentrations of cerium, viz. by a condensed spark between iron electrodes([5]). A comparison of the intensity of the fluorescence band of Ce in praseodymium solution with its intensity in standard solution of cerium has allowed to determine that the purest sample of praseodymium was prepared and kindly put to our disposal by Prof. I. N. Zaosersky. The concentration of cerium in it did not exceed $5 \cdot 10^{-3}$% (referring to praseodymium). Rolla's Pr oxide furnished by Hilger contained approximately ten times more Ce.

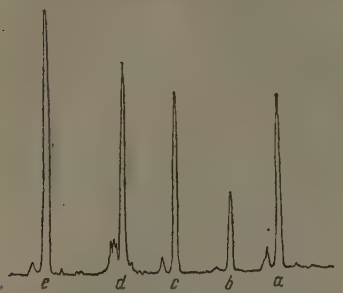

Fig. 1. Analysis of Zaosersky's praseodymium for cerium: *a*—intensity of the middle of the fluorescence band of Ce in 0.2% praseodymium solution; *b*, *c*, *d* and *e*—the same for Ce standard solutions with $6 \cdot 10^{-6}$, $8 \cdot 10^{-6}$, $1 \cdot 10^{-5}$ and $2 \cdot 10^{-5}$ % cerium respectively (a microspectrophotogram).

Special experiments have shown that in the case of the low concentration we have been working with, the intensity of fluorescence of cerium is in direct proportion with its concentration in the solution and does practically not depend on the presence of praseodymium in the same solution. In Fig. 1 is reproduced a microspectrophotogram of the intensity maximum of the fluorescence band of cerium, both in the solution of Zaosersky's praseodymium preparation and in a series of solutions of standard cerium preparations. The rest of possible admixtures in Pr are less dangerous. Nevertheless the preparation was carefully checked for the presence of other rare earths—especially of Ne—by means of the emission and absorption spectrum analysis.

Control experiments involved artificial contamination of the preparation with other rare earths in quantities sure to exceed those detected by the analysis ($5 \cdot 10^{-2}$% of Ce and 1% of Ne). In all these cases the absorption of the impurities added to Pr had no effect upon its absorption spectrum.

Our investigation has shown that the solutions of praseodymium salts possess one broad ($\sim$2150 cm^{-1} wide) absorption band in the ultra-violet, with a maximum approximately at 215 mμ. This band is observed only within a rather narrow range of praseodymium concentrations(0.06—0.17% with the absorbing column 2 cm long). At higher concentrations there appears a continuous absorption extending far towards the long waves, which may possibly be caused, at least in part, by the absorption of admixtures present in praseodymium. The aspect of the band is illustrated by curve *a* in Fig. 2. For the sake of comparison an absorption curve of pure water (*b*) is given too. As to the bands detected by Mukherji in a praseodymium solution, they should be referred not to praseodymium, but rather to cerium, present in Mukherji's preparation as an admixture.

The presence of an absorption of praseodymium lying in the interval 2100—2300 Å is also directly proved by the existence of the fluorescence of praseodymium solutions we have mentioned elsewhere([6]). The fluorescence spectrum of the solution of sulphate and chloride of praseodymium consists of three broad bands. Two bands are lying in the ultra-violet (220—265 and 265—310 mμ), while one is in the blue-green region of spectrum. The aspect of the ultra-violet fluorescence bands of praseodymium salts solutions is illustrated by Fig. 3. It is obvious that the emission of this fluorescence is connected with the absorption of light.

It ensues from Stokes' rule that the region of absorption should coincide with the region of spectrum, where the band of fluorescence with the shortest wave length is lying, or else shifted still further towards the short wave

lengths. This wholly agrees with the fact of praseodymium fluorescence being excited with maximum intensity by the wave lengths 2100—2300 A (by a condensed spark between nickel electrodes). The region of absorption thus coincides with the region of excitation. Strange enough that Lange, who certainly

Fig. 2. Absorption of praseodymium solution (*a*) and pure water (*b*) in the ultra-violet (a microspectrophotogram of plate sensitized with sodium salicylate).

was aware of the fact of existence of the fluorescence of praseodymium solutions, observed not only by us but also by Tomashek and Harres(7), neither took it into account, nor even mentioned it and did not go further than 44 000 cm^{-1}, although the absorption of Pr is quite perceptible already in this region, as can be seen from the photograph reproduced in Lange's article.

The band of absorption we have detected lies in the ultra-violet, where, according to Lange's calculations, at 42 088 cm^{-1} a band corresponding to the transition $4f^2\,{}^1S—4f^2\,{}^3H_4$ should be situated. However, there is reason to suppose that the band we have detected is connected not with this transition, but with that of an electron from the shell $4f$ onto the other shells of the ion PrIV, being thus similar to the bands of absorption of the ion CeIV(8). This is pointed to by the absence of an afterglow of Pr solutions (as in the case of Ce), by the diffuse aspect of the band and by a considerable discrepancy between the frequency of this band and the frequency calculated by Lange for the transition ${}^1S—{}^3H_4$. This discrepancy will be still larger, if we take for the term ${}^1S$ the value calculated by Mukherji(9). The fluorescence bands of praseodymium [as well as those of cerium(5)] do not fit within the scheme of terms of the ion PrIV. The study of this type of diffuse luminescence spectra of solutions of rare earths is in progress.

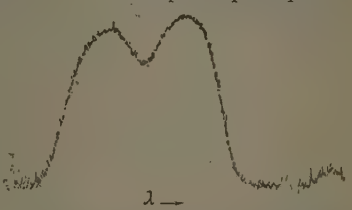

Fig. 3. Fluorescence of praseodymium solution in the ultra-violet (a microspectrophotogram of a plate sensitized with sodium salicylate).

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PHYSICS

EFFECT OF SODIUM, POTASSIUM AND LITHIUM SALTS INTRODUCED INTO THE FLAME ON THE INTENSITY OF THE RUBIDIUM LINE

By T. BOROVICK-ROMANOVA

(Communicated by W. I. Vernadsky, Member of the Academy, 23. X. 1938)

A very important problem of quantitative spectral analysis is that of the influence which the presence of various substances in the test has over the intensity of the spectral lines of the element being tested. This was pointed out already in the very earliest stages of development of spectral analysis(1).

This problem was studied recently by Lundegårdh(2) and Russanov(3). Russanov attributes the effect he observed to the change in the viscosity of the solution tested. D ıin, Granovsky and Puzenkin(4) studied the influence of various admixtures on the invariance of the homologous pair Mn—Co, using a spark as the source of light.

In 1937 some papers appeared dealing with the change in intensity of the lines of a series of elements when large quantities of NaCl and KCl are introduced into an arc with carbon electrodes. [Webb(5), Borovick(6), Mandelstam(7)]. In his paper the last author gives a theory for this extremely interesting phenomenon. Mandelstam explains this effect as being a result of the temperature of the arc changing. Jan van Galker(8)observed the action of alkalis on La and Ta lines in an interruption arc. Breckpot, Greffier and Perlinghi(9) studied the change in the intensity ratio for the homologous pair of Sb and Pb lines when Sn is present in the alloy.

This article gives the results of a study of the influence of various salts on Rb lines in an acetone vapour burner. This burner was chosen for solving the problem of spectroscopically determining the Rb content of sea-water without preliminary chemical treatment. The Rb content of sea-water is very small, in the hundred-thousandth parts of one per cent; for this reason a special method was required to solve this problem.

In choosing a source of light, we performed many preliminary experiments. By means of the arc we could get faint Rb lines in the sea-water precipitate, but the intense background hindered us in evaluating them, and the result obtained was not altogether definite. Consequently further investigations had the purpose of developing a flame method. We tried the oxygen-air flame, the Bunsen flame and the flame of the acetone vapour burner. The best results were obtained when the acetone vapour flame was used as the light source.

The device used to produce the flame was a carburetor which made a combustible mixture of acetone vapour and air. The carburetor was provided

with a manometer for measuring the pressure of the air, which was supplied by a compressor; besides this there was a device for regulating the temperature of the carburetor; the temperature had to be accurately regulated in order to keep up a constant flame-regime. From the carburetor the combustible mixture passed into a Mekker burner. By means of a pipette the solution under test was gradually dropped onto a strip of a solless filter, dried in a drying-cupboard at a temperature about 80°C. The dried strip was folded a few times and then fastened to a holder with a very fine platinum wire. The holder was a fork of platinum wire, melted into a glass tube. In this form the test was put into the flame along the axis of the spectrograph.

The photographs were taken on the Hilguer glass spectrograph. We used the most sensitive rubidium lines, which were situated in the infra-red region 7947.63 and 7800.3 Å.

The spectrum which we obtained was extremely simple. There were only eight lines in the sea-water spectrum: two K lines: 7664.94 and 7699.01 Å; two Na lines: 5889.965 and 5895.932 Å; two Rb lines: 7800.30 and 7947.63 Å and two Na lines: 8194.93 and 8183.33 which were not divided by the spectrograph. No other lines, besides these, were obtained in the sea-water spectrum.

In working with this burner we observed that large quantities of NaCl make the Rb lines fainter. In connexion with this we performed at the suggestion of Prof. S. A. Borovick some experiments to explain this fact. We took solutions containing 0.001% RbCl and various quantities of NaCl, viz. 0.1% NaCl, 1% NaCl and 4% NaCl. Table 1 gives some data on the blackening of the Rb line 7800.30 Å when the lines are microphotometered with a Zeiss microphotometer.

Table 1

Composition of test	Deviation value of the galvanometer *
0.001% RbCl + 0.1% NaCl	92.4
0.001% RbCl + 1% NaCl	38.4
0.001% RbCl + 4% NaCl	13.0

The experiments on the influence of NaCl on the Rb lines were repeated many times, using different concentrations of Rb, and always showed a definite pronounced weakening in the Rb lines.

Then we performed experiments to study the influence of KCl on the intensity of Rb lines. First of all the KCl was tested for pureness; no Rb lines were detected in its spectrum. We took solutions containing 0.001%RbCl and 0.1% KCl, 1% KCl and 5% KCl. The results are given in Table 2.

Table 2

Composition of test	Deviation value of galvanometer
0.001% RbCl + 0.1% KCl	66.5
0.001% RbCl + 1% KCl	57.5
0.001% RbCl + 5% KCl	53.0

* The deviation of the galvanometer corresponding to the mean background was taken as zero.

These data show that the Rb lines are weakened very little when KCl is added.

Besides this, a weakening in the intensity of the K lines was observed on photographs with sodium chloride. It is difficult to explain this difference in the action of KCl and NaCl through the difference in their excitation potentials, since the latter is insignificant and the excitation potential happens to be less for Rb lines than for the K and Na lines mentioned.

The difference in the influence of NaCl and KCl on Rb lines cannot be explained through the influence of the heat of evaporation, for NaCl, KCl and RbCl are close to each other and RbCl has the lowest heat of evaporation.

Let us examine the value, characterizing the stability of the molecules. Table 3 gives the values of the formation heats of the compounds in question.

Table 3

Formation Heat of Compounds in kcal/mole

	Na (S)	K (S)	Rb (S)
$\frac{1}{2}F_2$	— 136.6	— 124.5	— 132.8
$\frac{1}{2}Cl_2$	— 97.80	— 104.4	— 105.50
$\frac{1}{2}Br_2$	— 90.45	— 97.48	— 99.21
$\frac{1}{2}J_2$	— 76.50	— 85.20	— 87.21

This table shows that the formation heat of NaCl is less than the formation heat of RbCl and KCl. The formation heats of RbCl and KCl are very close to each other. It is possible that the difference in the influence of NaCl and KCl on Rb lines is due to the difference in the stability of the compounds. If this is so, it would seem that NaF should not have any weakening effect on the Rb lines.

Such experiments were performed. First of all the NaF was tested for pureness; no traces of Rb were detected in it. Then we photographed the spectra of solutions containing 0.001% RbCl and 0.1% and 4% NaF. The resulting data are given in Table 4.

Table 4

Composition of test	Deviation value of galvanometer
0.001% RbCl + 0.1% NaF	90.3
0.001% RbCl + 4% NaF	93.8

Thus, NaF actually has no weakening effect on Rb lines.

We also studied the influence of NaBr and NaJ on Rb lines. Tables 5 and 6 give the results of these experiments.

Table 5

Composition of test	Deviation value of galvanometer
0.001% RbCl + 0.1% NaBr	197.5
0.001% RbCl + 1% NaBr	112.5
0.001% RbCl + 4% NaBr	46.0
0.001% RbCl + 7% NaBr	14.5

Table 6

Composition of test	Deviation value of galvanometer
0.001% RbCl + 0.1% NaJ	184.8
0.001% RbCl + 4% NaJ	112.4
0.001% RbCl + 10% NaJ	35.9

NaBr and NaJ make the Rb lines considerably fainter, as may have been expected, since their formation heats are so small.

Besides this, we performed experiments with solutions containing 0.001% RbCl and 0.1%, 4% and 10% Na_2SO_4 (formation heat 330.1 kcal/mole). In this case no weakening of the Rb lines was detected.

If lithium (formation heat 98.70 kcal/mole) is added to a 0.001% solution of RbCl, the Rb lines are weakened a little less, than if NaCl is added.

The following conclusions can be drawn from these experiments:

1. NaCl, NaBr, NaJ and LiCl show a weakening effect on Rb lines.

2. KCl, NaF and Na_2SO_4 either weaken the intensity of Rb lines insignificantly or do not weaken them at all.

3. A relation seems to exist between the value of the formation energy of the compounds and their weakening action on the intensity of Rb lines.

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BIOCHEMISTRY

SUGAR FERMENTATION OF CELLULOSE BY THERMOPHYLIC BACTERIA

By A. IMSHENETZKY

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It seems that cellulase is a ferment encountered in bacteria and fungi exclusively and that only by the activity of these organisms can we explain the destruction of large amounts of cellulose, which takes place under natural conditions. Of late the attention of microbiologists is attracted by bacteria, which ferment cellulose at high temperatures. This interest is due to the fact that in thermophylic fermentation cellulose is being speedily decomposed and is accompanied by the formation of alcohol and volatile acids. However, our notions regarding this biochemical process are based on studies of mixed cultures and the physiology of cellulose bacteria remains far from clear.

It is evident that the products mentioned can accumulate only after soluble carbohydrates have appeared in the medium and have been fermented by cellulose and concomitant microbes. In cultures of thermophylic bacteria such a hydrolysis of cellulose must proceed at a greater rate than when mesophylic forms of bacteria are developed, which destroy cellulose much more slowly. It could be also presumed that under these conditions it would be unnecessary—for the purpose of accumulating sugars in the medium—to introduce into the medium antiseptics paralysing the fermenting capacity of the bacteria and leaving the hydrolysis capacity unaffected.

Researches, the results of which are described below, have been conducted with pure cultures of an anaerobic bacterium, isolated by me and developing on cellulose at 60° C.

The isolated bacteria are rods forming terminal spores. Developing under anaerobic conditions on bits of filtering paper they colour it yellow and ferment cellulose in the course of 4—5 days. After the end of fermentation an amorphous yellow sediment consisting of unfermented cellulose and bacterial cells is left at the bottom of the test tube. The bacteria do not develop in cellulose containing mineral media, which are usually employed for obtaining elective cultures of cellulose bacteria. The fermentation of cellulose in synthetic media becomes possible only if complex nitrous compounds are introduced into them. A good growth is obtained if albumen, fragments of internal organs of animals, meat-peptone broth, faecal extract or decoctions of various bacterial cells are additionally introduced into the media. The bacteria do not assimilate mineral nitrogen even after the introduction of bios (yeasts) into the media. In its taxonomic position this species of bacteria is nearest to the *Bacillus cellulosae dissolvens*. A detailed descrip-

tion of the methods of its isolation in pure culture and of its biology will be supplied in a separate report.

In studying the ability of the bacteria to produce sugar from cellulose, the following medium was employed for their cultivation: $NaNH_4HPO_4 4H_2O$ —1.5; KH_2PO_4—0.5; K_2HPO_4—0.5; $MgSO_4$—0.4; NaCl—0.1; 1% solutions of $MnSO_4$ and $FeSO_4$—one drop of each; peptone—5.0; $CaCO_3$—20.0; tap water—1000.0. To 750 cm³ of this medium 250 cm³ of a 10% watery phaecal extract was added. The pH of the medium was 7.4.

Dried weighed portions of cellulose (bits of filtering paper) were put into round 300 cm³ flasks and 250 cm³ of the medium was poured into each flask. After sterilization and inoculation with 25 cm³ of an old culture, the surface of the medium was covered with a high layer of sterile vaseline oil. The flasks were incubated at 60° C. Fermentation began usually on the next day, but it was not always equally intense in every flask. This explains the different ratio of fermented cellulose in parallel tests.

The duration of the tests varied between 4 and 17 days. The results were determined and registered in the following manner. The vaseline oil was sucked off the surface of the medium, a certain amount of the culture was poured off and filtered, and sugar determined in the filtrate according to the method of Bertrand. After this hot 1% hydrochloric acid was poured into the flasks to dissolve chalk and the entire contents of the flasks were filtered. The undecomposed cellulose remaining in the filter was washed with water, dried and weighed. In this way the amount of decomposed cellulose was determined. The results of two series of such experiments are summed up in the table.

Accumulation of Sugar in Cultures of Thermophylic Cellulose Bacteria

Duration of test (days)	4	4	8	8	12	13	16	17
No of flasks	1	5	2	6	7	3	8	4
Cellulose introduced (g)	5.33	5.24	5.33	5.23	5.27	5.33	5.25	5.33
Cellulose decomposed (g)	1.17	0.30	1.60	1.66	2.29	2.05	2.51	1.91
Cellulose decomposed (%)	21.95	5.72	30.01	31.74	43.47	38.46	47.81	35.83
Sugar in medium (g)	0.47	0.19	0.85	0.77	1.56	1.53	1.19	1.09
Sugar in medium (%)	0.17	0.07	0.31	0.28	0.42	0.41	0.45	0.41
Ratio of sugar to decomposed cellulose (%)	40.17	63.33	53.12	46.38	68.12	74.63	47.41	57.07

The analysis of these data allows to draw the following conclusions:

1. Thermophylic bacteria provoke the hydrolysis of cellulose, and in their cultures, irrespective of their age, sugar can be regularly discovered.

2. There is a direct relation between the decomposition of cellulose and the formation of sugar.

3. The sugar which is formed is fermented in a varying degree in the different tests. Therefore the ratio of accumulating sugar to decomposed cellulose varies within relatively wide limits (between 40.17 and 74.63%).

By adding hydrochloric phenylhydrosin and sodium acetate to the filtered contents of the flasks, crystals of phenylozazon of glucose with a melting point at 204—205° were obtained. It should be expected consequently that not only cellulose but glucose as well might form a source of energy for these anaerobic bacteria. Transfers to the medium described above, to which 1% of glucose had been added, confirmed this assumption: the bacteria develop under these conditions and ferment glucose. Thus, the fermentation of cellulose is practically nothing else than fermentation of glucose and pos-

sibly of some other soluble carbohydrates, forming as the result of the hydrolysis of cellulose. But only an insignificant part of these carbohydrates is fermented by cellulose bacteria, the rest remaining in the medium unconsumed. Natural enough, that in mixed cultures this remaining sugar is being utilized by the concomitant bacteria and, according to physiological properties of these symbionts, various products are accumulated in the medium in various amounts. Among other things I was able to observe that the absence of reducing substances or a considerable decrease in their content always indicates the contamination of the cultures by alien microorganisms able to utilize sugar.

The fact that the hydrolysis of cellulose proceeds much more intensively than the fermentation of the soluble carbohydrates following upon it, is of indubitable interest for the biologist. In some of our tests only about 25% of the decomposed cellulose was utilized by the bacteria as a source of energy, the rest having been hydrolyzed, though accumulated in the form of sugars. The following hypothesis may be suggested. Anaerobic cellulose bacteria belong to those microorganisms which under natural conditions always exist in extremely close symbiotic relations with other bacteria (this very fact may possibly account for the difficulty of isolating them in pure culture). Utilizing glucose, the concomitant microbes in their turn exert a favourable influence on the development of cellulose bacteria—by accumulating organic nitrogen they need, by lowering the potential of the medium and by consuming the toxic products of their metabolism. One becomes convinced of the correctness of this assumption by comparing the intensity of cellulose fermentation in pure and mixed cultures respectively. In the latter case it proceeds much more speedily. When we isolate the bacteria in pure culture, we disturb a historically developed symbiosis and create conditions, which are unusual for the cellulose bacteria, conditions under which the carbohydrates formed fail to be consumed by the concomitant bacteria.

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HYDROBIOLOGY

THE LOWER LIMIT OF THE BOTTOM FAUNA AND ITS DISTRIBUTION IN THE BLACK SEA

By V. N. NIKITIN

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It is common knowledge that an outstanding feature of life conditions in the Black Sea is the absence of deep sea life, except the existence of anaerobic bacteria.

In this connexion, the question of the range of vertical distribution of organisms and determination of the volume of water and the size of areas harbouring living organisms, both planktonic and benthonic, assumes great importance.

The above data are of fundamental value in the study of the general problem of productivity of the sea and are closely connected with a number of questions of ecological and economic nature.

N. I. Andrusov[1] and A. M. Ostroumov[2] were the first to establish during expeditions in 1890—91 the fact of non-existence of living organisms of plankton and benthos in the depths of the Black Sea below 100 fathoms (183 m). Subsequently (in 1902—11) their statement was substantiated by S. A. Zernov[3] who had found at several stations that no living organisms of benthos occurred at depths of 166—167 m. In 1923—27 upon investigations of the Azov-Black Sea Scientific and Economic Research Expedition, according to data by N. M. Knipovich[4], the deepmost living benthonic organisms were found near the coasts of Crimea at a depth of 144 m and those of Caucasus at 155—172 m.

During Black Sea expeditions within the period of 1924—34 (conducted by the Central Hydrographic Bureau and the Batumi Scientific Fisheries Station of Georgia) we have taken 208 stations outlining the limits of benthos range. These data permit of determining not only the depth limits which may be reached by living aerobic forms of benthos, but also to draw the downward limit of benthonic life along the entire Black Sea coast, at the same time to determine the size of areas of the sea floor, occupied by living organisms, to elucidate the qualitative and quantitative composition of animal communities and the ecological conditions characterizing the boundary life-zone of the sea.

The works connected with determination of the range of distribution of benthos have been carried out by means of a Pettersen-grab and only in single cases by a dredge.

In view of the fact that the downward limit of benthos in the Black Sea runs mainly along rather steep slopes of the bottom, it is impossible

by means of a dredge to ascertain with any degree of accuracy the depth and position of stations at which samples have been taken. As a result, the data obtained by K. Jagodovsky near Batumi in 1908(5) were no doubt erroneous in that he believed to have dredged up living organisms of benthos from depths of 200 m.

According to a number of ecological and other conditions, the littoral zone of the Black Sea may be divided into several regions. We have delimited six regions with the lower limit of benthos passing at various depths, namely:

1. South Coast of Crimea. Benthos boundary passes at depths of 127—135 m, mostly 5—10 miles from the shore. In the eastern part the distance increases to 24—26 miles off-shore, while in the west the aforesaid boundary runs within 3—2 miles off-shore. The total bottom area colonized by living organisms of macrobenthos is about 6800 km².

2. Caucasian Coast. Benthos boundary passes at depths of 135—165 m, mainly 3—5 miles off-shore. In the north the distance from the shore attains 10—25 miles, while in the south it is sometimes one and even one-half of a mile off-shore. The total area of the floor of the «living zone» is about 6000 km².

3. South Coast of the Black Sea (Anatolia). Benthos boundary passes at depths of 130—135 m, in the most part 2—5 miles off-shore, though occasionaly approaching it within a mile or less than that. Total area of the «living zone» floor—9500 km².

4. Bosporus Region. Benthos boundary ranges within depths of 170—250 m, 11—16 miles off-shore. Total area of the «living zone» floor equals 2900 km².

5. West Coast of the Black Sea. Benthos boundary runs through depths of 125—127 m, at a distance of 20 to 60 miles from the shore in the northern part. Total area of the «living zone» floor—12 500 km².

6. North-Western Part of the Black Sea. Benthos boundary passes at depths of 115—125 m, 60—120 miles off-shore in the west and 30—10 miles in the east. Total area of the «living zone» floor is about 57 600 km².

The limited range of vertical distribution of planktonic and benthonic organisms in the Black Sea is due primarily to the absence of oxygen in the depths, as a result of a limited vertical circulation of sea waters, which again depends upon variations in the density of water, the density of deep water layers generally exceeding that of the surface layers.

In 1929(6) we determined the lower limit for plankton in the Black Sea and made an attempt to determine the volume of waters inhabited by living planktonic organisms. At the same time we succeeded in ascertaining that in the central parts of the sea the aforesaid limit passes at 125—100 m and even upwards, while in the littoral zone it sinks down to depths of 150—175 m. As far as the benthos in concerned, its downward limit, as may be seen from the aforesaid, lies above the one of plankton in the littoral zone. Thus, such specific environmental conditions as insufficient supply of oxygen, accumulation of CO_2 and the presence of H_2S prevailing in the bottom waters, are limiting the range of distribution of organisms in the deeper layers of the sea, i. e. for benthos the limit lying at higher horizons than for plankton thriving in the free depths of the sea. The difference is caused by those processes of mineralization of organic matter, taking place on the surface of the bottom and in the upper layers of the bottom ground, which absorb the last remnants of oxygen penetrating thither.

Under such conditions neither benthonic forms most adapted to scarcity of oxygen, nor facultative anaerobic forms are able to exist, and consequently

a downward limit is formed for benthos, somewhat above the limit for plankton in the littoral zone of the Black Sea.

As regards the variations in the position of the lower limit of benthos in different regions of the sea, such variations are connected with a number of hydrological and other factors. Therefore the uppermost boundary for benthos, as well as the boundary for plankton near the western coast of the Black Sea, depend on the supply of oxygen which is scarcer in these than in other regions, as a result of a still more limited vertical circulation of waters, owing to considerable dilution of the upper layers of the sea, produced by inflow of fresh waters from the Danube, Dnieper and other rivers.

The lowermost boundary of benthos and plankton (at a depth of 200 m and downward) in the Bosporus region is due to the presence of oxygen which is carried into greater depths by the lower Bosporus current. The invasion of the Bosporus region by a number of Mediterranean forms, both benthonic and planktonic, not occuring in other regions of the sea, is also due to the effect of the above-mentioned current.

The limiting depth for benthos near the coast of Crimea, Caucasus and Anatolia depends upon the prevalence of one or a combination of many effects of such factors, as the outflow and inflow of waters, the nature and velocity of currents, the bottom relief and the like, bearing upon penetration of oxygen to greater or smaller depths. In some cases the position of the lower limit for benthos may depend not upon the supply of oxygen, but upon specific conditions, as for instance, in some parts of the Batumi region, where the bottom currents are generally accompanied by shifting of the bottom sediments, benthonic organisms are not to be found at depths of 100 m and even of 85 m.

Irrespective of depths, the essential conditions bearing on the boundary zone of benthos are uniform throughout all the regions: shortage of oxygen (2—5%), a relatively high tension of carbon dioxide (pH=7.7—7.6), the periodical disappearance of oxygen and accumulation of H_2S, a constant temperature (8.2—8.3°C) and salinity (20‰), feeble penetration of light, considerable retardation of mineralization processes of organic matter and, finally, extreme paucity and periodical disappearance of plankton in the bottom layers.

Owing to such peculiar ecological conditions, the boundary zone of benthos should be considered as a specific facies of mud-biotope, and its population isolated into a separate biocoenothic group. This group comprises 11 species (see table), the dominant among them being: *Melinna palmata* Grube, *Cerianthus vestitus* Frbs, *Modiola phaseolina* Phil. and *Amphiura florifera* Frbs. These forms are not only distinguished by their ability to persist under conditions of great shortage of oxygen, but to survive after periods of totally anaerobic conditions with the presence of free H_2S and a considerable quantity of CO_2. The remaining forms are secondary components of the biocoenosis, and their composition may vary under the influence even of slight changes of ecological conditions in different sea regions.

On counting the organisms in this facies of the mud-biotope which we call the «benthonic limit zone» (see table), we derived for the total area of the aforesaid zone an average of 33 specimens per 1 m². For some sea regions the range varies between 15 specimens in the north-western part of the sea and 52 specimens near the coast of Caucasus.

This rate of density of population appears to be rather insignificant as compared to the overlying zones of mud-biotope. Thus, for instance, near the Caucasian coast, according to our calculations, the quantity of organisms per 1 m² is on the average 465 specimens at depths of 100—130 m and 1940 specimens at 70—100 m.

Sea regions	1 South coast of Crimea		2 Coast of Caucasus		3 South coast of the Black Sea (Anatolia)		4 Bosporus region		5 West coast of the Black Sea		6 NW part of the Black Sea		7 Boundary zone along all Black Sea coasts	
Limiting depths	120—135		130—160		120—130		150—170		120—125		110—125		110—170	
Quantitative index *	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*
Melinna palmata Grube	53	9	83	44	75	25	100	12	67	10	33	5	68	22
Cerianthus vestitus Frbs.	53	3	17	1	37	3	67	5	67	13	67	4	40	3
Modiola phaseolina Phil.	26	3	13	2	37	4	0	0	67	7	67	3	27	3
Amphiura florifera Frbs.	21	1.6	17	1.5	50	3	67	7.5	33	7	0	0	24	2
Terebellides strömi Sars	10	0.4	4	0.5	0	0	0	0	33	3	17	1	8	0.6
Nephtys cirrosa Ehlers	5	?	13	2	13	0.8	0	0	33	?	0	0	10	0.75
Suberites domuncula Schd.	10	0.8	9	0.75	13	0.8	0	0	0	0	0	0	8	0.6
Cucumaria orientalis Ostr.	0	0	0	0	0	0	33	2.5	0	0	0	0	2	0.12
Ctenicella appendiculata (Hell.)	0	0	0	0	0	0	33	2.5	0	0	17	1	3	0.25
Eugira adriatica Drasch.	10	0.8	0	0	0	0	0	0	0	0	0	0	3	0.25
Syndesmia alba Wood.	0	0	0	0	0	0	0	0	0	0	17	1	2	0.12
Total	—	19	—	52	—	37	—	30	—	40	—	15	—	33

* *A*—frequency of occurrence in %. *B*—density of population (number of specimens per 1 m²).

In summing up the data referring to all the sea regions, we derive the total area of the floor occupied by macrobenthos as equivalent to 95 300 km², constituting about 23% of the entire bottom area of the Black Sea.

Thus, as a result of peculiar hydrographic conditions of the Black Sea, more than $^3/_4$ of its bottom surface and, as we succeeded in demonstrating(6), over 88% of the volume of waters, are barren of living aerobic organisms of benthos, plankton and nekton.

The above-mentioned peculiar features of the ecological conditions of the Black Sea cannot but affect its fundamental metabolic processes.

Organisms composing the population of the pelagic zone of the Black Sea, incessantly dying off in enormous quantities, sink to the anaerobic depths of the sea, where only part of them are exposed to processes of mineralization, the other part remaining entombed in the bottom sediments of the sea. This is fully corroborated by statements of A. D. Archangelsky(7) and M. I. Rawitsch(8) regarding the quantity of organic matter in the bottom deposits of the Black Sea.

Thus, the elimination of considerable masses of organic matter from the cycle of biogenic elements constitute another highly peculiar feature of the Black Sea.

This constant loss of biogenic elements should be compensated by the inflow of fresh water masses into the sea. In this connexion, a quantitative study of the continental inflow and its rôle in the general problem of the metabolism of the Black Sea assumes great importance.

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GENETICS

THE INFLUENCE OF INTRACHROMOSOMAL AND INTERCHROMOSOMAL RELATIONS UPON THE RESULTS OF INBREEDING AND CROSSING

By M. L. KARP

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Different hypotheses to explain heterosis (hybrid vigour) on a genic basis were proposed by Jones(1) and East(2). These hypotheses offer, however, no comprehensive solution of the problem. The immediate purpose of the present work was a study of the influence of the mode of co-operation of hereditary factors upon the inbreeding-depression and heterosis.

The most suitable object—*Drosophila melanogaster*—was used for the work. By means of a series of subsequent crossings different lines of flies were obtained which differed genetically only in definite chromosomes or in single chromosome-sections. The comparison of these lines with each other in respect to viability, longevity and fertility under the same cultural conditions made it possible to reveal the influence of individual chromosomes and chromosome-sections upon the aforementioned characters.

Eighty-six types of flies were investigated. About 125 000 flies and 500 000 eggs were examined.

The genetical study of the material obtained has shown that differences in viability, fertility and longevity of different types of flies were depending genetically upon the presence in their sex-cells of definite chromosomes in homozygous or heterozygous condition. Flies heterozygous for one chromosome pair were distinguished by a greater viability, fertility and longevity, as compared with those bearing the individual components of each pair in homozygous condition. Heterozygosity for two pairs of chromosomes proved to be more favourable than heterozygosity for one pair of chromosomes. Flies which were more homozygous were in the majority of cases surpassed with respect to all the characters studied by those of lower homozygosity.

The present work has thus confirmed the correctness of the starting point of the genetical explanation of heterosis, i. e. that heterosis is genetically caused by heterozygosity of chromosomes. However, this work presented at the same time facts which do not fit into the schemes constructed on such a basis. Flies of the Berlin and Samarkand populations obtained from free crossing were in many cases behind of highly homozygous ones with respect to fertility and longevity, This could be explained on the assumption that flies from the population could on the average possess a worse set of genes and could on the average be less heterozygous than flies from

uniform lines which were heterozygous only for definite chromosomes. In some cases, however, flies possessing definite chromosome-sections, which were marked by recessive genes, were not less viable and fertile and sometimes even more viable and fertile than those, which possessed these sections in heterozygous condition. These facts, as well as the data which supplied ground to East for his critique of Jones and Richey's data([3]) which support the hypothesis of Jones, and facts by Jones and Singleton([4]), and the data presented by Mangelsdorf, too, which are not explained by the scheme of East, lead to the conclusion, that absolutization of any sort of relation between allelomorphs of individual genes cannot be admitted; one should admit the existence of different sorts of co-operation of allelomorphs.

No matter which sort prevails, the possibility of inbreeding and crossing is to a great extent dependent on the type of summation of differences in individual genes. On our material we were able to observe successive accumulation of the action of individual chromosome-sections. Such cases are demonstrated in Table 1.

Table 1

Fertility and Longevity of the Flies, Homo- and Heterozygous for Various Sections of a Chromosome

Name of the line	Fertility $M \pm m$	Longevity $M \pm m$
$\frac{+\ +\ +\ +\ +\ +\ +\ +}{ru\ h\ th\ st\ cu\ sr\ e\ ca}$	53.2 ± 1.6	32.4 ± 1.3
$\frac{ru\ +\ +\ +\ +\ +\ +\ +}{ru\ h\ th\ st\ cu\ sr\ e\ ca}$	49.5 ± 1.7	26.5 ± 1.5
$\frac{ru\ h\ th\ st\ +\ +\ +\ +}{ru\ h\ th\ st\ cu\ sr\ e\ ca}$	29.6 ± 1.3	25.9 ± 1.1
$\frac{ru\ h\ th\ st\ cu\ sr\ e\ ca}{ru\ h\ th\ st\ cu\ sr\ e\ ca}$	17.8 ± 1.2	16.8 ± 0.8
$\frac{+\ +\ +\ +\ +\ +}{dp\ b\ pr\ c\ px\ sp}$	41.0 ± 1.6	33.2 ± 1.9
$\frac{+\ +\ +\ c\ px\ sp}{dp\ b\ pr\ c\ px\ sp}$	33.0 ± 1.6	20.3 ± 1.7
$\frac{dp\ b\ pr\ c\ px\ sp}{dp\ b\ pr\ c\ px\ sp}$	0	5.6 ± 0.5

There are, however, in our investigation cases when striking changes in the effect of accumulation take place; they are caused by new combination of genes or by strong alteration of the developmental conditions. The line 1026 obtained by us is typical in this respect. As may be seen from Table 2, an addition of the chromosome-section, marked with recessive gene *pr*, to the section *c px sp* $\left(\frac{+\ +\ +\ c\ px\ sp}{dp\ b\ pr\ c\ px\ sp} \rightarrow \frac{+\ +\ pr\ c\ px\ sp}{dp\ b\ pr\ c\ px\ sp}\right)$ produces no further change for the worse, but, on the contrary, a striking increase in vigour and productivity of the flies. Addition of the section *dp b* to the section *pr c px sp* strikingly weakens the flies, the effect being wholly disproportional to the strength of action of the section in another genotype.

Table 2

Relative Viability, Fertility and Longevity of the Flies Homo- and Heterozygous for Various Sections of the Chromosome *dp b pr c px sp*

Line number	Name of the line	Viability in %	Fertility (absolute) $M \pm m$	Fertility in %	Longevity (absolute) $M \pm m$	Longevity in %
985	$\frac{+\ +\ +\ +\ +\ +}{dp\ b\ pr\ c\ px\ sp}$	100.0	41.0 ± 1.6	100.0	33.2 ± 1.9	100
986	$\frac{+\ +\ +\ +\ px\ sp}{dp\ b\ pr\ c\ px\ sp}$	116.4	41.8 ± 1.0	102.0	25.4 ± 1.7	77
1002	$\frac{+\ +\ +\ c\ px\ sp}{dp\ b\ pr\ c\ px\ sp}$	94.6	33.0 ± 1.6	80,5	20.3 ± 1.7	60
1026	$\frac{+\ +\ pr\ c\ px\ sp}{dp\ b\ pr\ c\ px\ sp}$	113,6	43.2 ± 1.3	105.5	29.8 ± 0.9	90
	$\frac{dp\ b\ pr\ c\ px\ sp}{dp\ b\ pr\ c\ px\ sp}$	43.6	0	0	5.6 ± 0.5	16.9
1037	$\frac{dp\ +\ +\ +\ +\ +}{dp\ b\ pr\ c\ px\ sp}$	—	36.6 ± 1.9	89·3	—	—
1036	$\frac{dp\ b\ pr\ +\ +\ +}{dp\ b\ pr\ c\ px\ sp}$	—	35.3 ± 1.4	86·1	—	—

The chromosome $\frac{sc\ v\ f\ ca}{sc\ v\ f\ ca}$, in homozygous condition, decreases the viability of flies by 52% against the $\frac{D}{+}$ background (when one compares flies $\frac{sc\ v\ f\ ca}{sc\ v\ f\ ca}\frac{+}{+}\frac{D}{+} : \frac{+}{+}\frac{+}{+}\frac{D}{+}$), while against the $\frac{Cy}{+}$ background (when one compares $\frac{sc\ v\ f\ ca}{sc\ v\ f\ ca}\frac{Cy}{+}\frac{+}{+} : \frac{+}{+}\frac{Cy}{+}\frac{+}{+}$) it increases the viability of flies by 32%.

Our data show that the results of inbreeding and crossing cannot be reduced to a mere accumulation of hereditary differences. In every individual, in every highly homozygous line or uniform heterozygous culture there occurs a certain deviation from the simple summation of the action of hereditary facts. The deviations may be insignificant and barely perceptible or very strong. Homozygosity for a small number of genes may prove lethal owing to several genes acting highly infavourably upon the organism when present in a definite combination. A highly homozygous culture may exhibit high viability and productivity owing to genetic harmony in its structure.

However, it would be a mistake to conclude from some cases of complex interaction that interaction is omnipotent. Interaction modifies the effect of specific accumulation of hereditary elements in case of a given combination of genes. In case of another genic combination, when a new mutation arises or when crossing takes place, the results of a certain accumulation may become manifested to a full extent.

In a genetically heterogeneous population the deviations due to a simple summation are mutually neutralized. For the improvement of the hereditary base of a plant- or animal population a decisive rôle is therefore played by enrichment of the population with more favourable hereditary material.

Our experiments thus lead to the following conclusions:

1. The manifestation of heterosis depends on various sorts of co-operation of homologous genes, on the genotype as a whole and on the conditions under which the organism is developing.

2. Highly homozygous cultures in the overhelming majority of cases show a certain degree of depression. Nevertheless the possibility of obtaining commercially valuable forms as a result of inbreeding is quite real in connexion with the fact that, apart from the possibility of accumulating specific genes, there is a chance of occurrence of favourable genic combinations. The effectiveness of inbreeding is to a considerable extent determined by the qualities of the original population and by the methods applied in selecting material for inbreeding.

3. A given inbred line which had no value by itself may prove to be very valuable in case a corresponding partner be selected to match it: F_1 from crossing two inbred lines may differ in greater vigour and productivity as compared with the original population, as the latter may on the average possess a worse set of genes and may be on the average less heterozygous than the hybrid obtained from inbred lines, which were properly selected and fitted to each other.

4. In connexion with the specifity of genetic constitution of different inbred lines and with the dependence of their properties not only on the action of individual genes, but also on the sort of their combination in each line, different results are possible when these lines are crossed: strong manifestation of heterosis, absence of heterosis and even negative heterosis.

5. An inbred line which is behind of the population in vigour and productivity may improve the hereditary base of the population owing to enrichment with better hereditary material and owing to supplanting of inferior ones when crossed with the population.

The work on the inbreeding in Indian corn which was recently conducted in the United States of North America is of great interest in connexion with our conclusions. Several tens of well tested hybrids of corn obtained from inbred lines and better yielding than the original open pollinated varieties are already turned over to practical growers. The uniformity of the plants (of sugar-corn) has practically revolutionized the mechanization and all the methods of sugar industry and has given inprecedented savings. As a result of careful selection and fitting it proved possible to create hydrids fitted to various ecological conditions and giving good results from year to year. Such is the hybrid Golden cross Bantam which is fitted to many parts of the country and gives good yields from Maine to Illinois (about 2000 km), a result of crossing two inbred lines, one of which, Purdue 39 produces more corn than the open pollinated variety Golden Bantam from which it has been originated. Altogether in the United States of North America 15 million acres were occupied in 1938 with hybrids between inbred lines which gave a surplus of 100 million bushels of corn. All this speaks for the great practical significance of the inbreeding work.

In the United States of North America there was done an interesting work on the study of the effectiveness of different schemes of crossing of the inbred lines. It was proved that crossing of hybrids between inbred lines with each other (double cross, multiple cross) usually yields better results than single cross. Promising and most practicable proved to be crossing of inbred lines with the open pollinated variety (the top cross).

Experience has shown that the best inbred lines yield best results under any scheme of crossing. We find it expedient in this connexion to draw the attention of plant-breeders to the necessity of employing plants of the top cross as an original material for inbreeding. This would allow to begin in-

breeding by a genetical analysis of a large number of gametes and would help to make in F_1 better selection of plants for further work.

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TAXONOMY

A NEW SPECIES OF WHEAT, *TRITICUM ARMENIACUM* (JAKUBZ.) sp. n.

By E. N. MAKUSHINA

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Wild emmer, collected by T. Kotchi in 1855 in Palestine, was first described by Körnicke as *Triticum vulgare* var. *dicoccoides*. In 1913 Schulz ranked it as an independent species, *T. dicoccoides* Körn.(5), considering it to be the progenitor of the group of cultivated emmers. The principal area of distribution of *T. dicoccoides* Körn. embraces Syria, Palestine and Transjordania; occasionally it is found in Asia Minor, Mesopotamia and Iran.

In 1929—30 M. G. Tumanyan first found large amount of wild emmer in Armenia (near Erivan); he referred it to the species *T. dicoccoides* Körn., but placed it in a special Armenian section(1). In 1931 M. M. Jakubziner found wild emmer in the Nakhichevan autonomous republic, thus extending the area of distribution of this species all over Transcaucasia. The peculiar complex of characters proper to Armenian forms caused Jakubziner to classify them as a special subspecies *armeniacum* (Figs. 1 and 2), in contradistinction to the subspecies *syrio-palestinicum* Flaksb.(3).

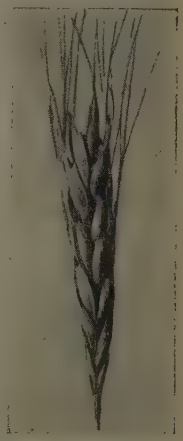

Fig. 1. Spike of *T. armeniacum* (*T. dicoccoides* Körn. ssp. *armeniacum* Jakubz.) sp. n.

Ssp. *syrio-palestinicum* is quite polymorphic, embracing many varieties. According to a number of characters, chiefly of quantitative nature, these varieties fall into two natural groups: (1) pr. *horanum* Vav.—narrow-spiked (Horan and Southern Syria); (2) pr. *judaicum* Vav.—broad-spiked (Palestine, Ezdrelon valley).

Ssp. *armeniacum* is less polymorphic, embracing three chief varieties: red-spiked (var. *nachitschevanicum* Jakubz.), white-spiked (var. *Tumaniani* Jakubz.), and black-spiked (var. *nigrum* Tum.), the latter encountered very rarely. An Iran form (a single sample collected by Strauss in 1910) was referred by Jakubziner to ssp. *armeniacum* var. *Tumaniani* Jakubz. In addition to the characters they possess in common with the Palestinian subspecies such as brittle spike, prostrate stems etc., the chief distinguishing characters of Armenian wheats are: ciliate pubescence of the leaf blade and sheath, waxy bloom, absence of varieties having pubescent spikes, less variation

in quantitative characters of the spike, winter type, adaptability to mountain regions. Detailed descriptions are given in the papers by Tumanyan(2) and Jakubziner(4).

In the present investigation we undertook a more detailed cytogenetic study of *T. dicoccoides* Körn. The following varieties of ssp. *syrio-palestinicum* Flaksb. were taken for analysis: var. *arabicum* Vav. (pr. *judaicum* Vav.), var. *pseudo-jordanicum* Jakubz. (pr. *horanum* Vav.) and var. *spontaneo-nigrum* Flaksb. (pr. *horanum* Vav.). Ssp. *armeniacum* Jakubz. was represented by its two principal varieties: var. *nachitschevanicum* Jakubz. and var. *Tumaniani* Jakubz. All these forms of *T. dicoccoides* Körn. were crossed with the following representatives of the three groups of wheat: *T. spontaneum* Flaksb. ssp. *Thaoudar* Reut., *T. monococcum* L. gr. *albo-Hornemanii* Flaksb., *T. durum* Desf. var. *arraseita* Körn., *T. durum* Desf. gr. *hordeiforme* Host. 010, *T. dicoccum* Schrank ssp. *georgicum* Dekapr. et Men., *T. dicoccum* Schrank var. *atratum* Host., *T. persicum* Vav. var. *fuliginosum* Zhuk., *T. vulgare* Host. gr. *erythrospermum* Körn., *T. vulgare* Host. gr. *caesium* Al. 0111, *T. macha* Dekapr. et Men.,and *T. spelta* L. It was difficult to establish any regularity in crossability, since the ratio of kernels set varied greatly in different combinations. The F_1 hybrids were sown in the spring of 1937 at Pushkin (near Leningrad). In all there were 306 hybrid plants from crosses with the Palestinian subspecies and 163 from crosses with the Armenian.

Fig. 2. Spiklet, glume and kernel of *T. armeniacum*.

An analysis of the hybrids at the time of flowering showed that those between the Armenian and Palestinian subspecies proved totally sterile, and that, when these forms were crossed with other species of wheat, the hybrids obtained behaved quite differently. All the hybrids from crosses with *armeniacum* proved to be sterile; open florets had dry, indehiscent anthers, containing empty pollen grains. Only occasional pollen grains contained stainable protoplasm, and even these, apparently, were not all functional. In the table are given data characterizing the behaviour of hybrids from crosses between ssp. *armeniacum* and the 28-chromosome group of wheats. From these data it may be seen that there is not only complete sterility in the case of bagged spikes (self-pollination), but only slight viability of the egg-cells in the case of backcrosses or open pollination too. According to the data of an investigation by V. V. Svetozarova, ssp. *armeniacum* $\times$ $\times$ *T. Timopheevi* Zhuk. hybrids are also sterile. Hybrids from crosses between *armeniacum* and 14- and 42-chromosome wheats were completely sterile, with the exception of the combination *T. macha* $\times$ ssp. *armeniacum*, in which case from 211 flowers from a backcross two very shrivelled kernels were obtained, which did not germinate.

Hybrids from crosses with Palestinian forms behaved in different ways, according to the chromosome number of the parents. The F_1 from crosses with einkorns was completely sterile (there was obtained only one kernel from unbagged spikes). In hybrids from crosses with 28-chromosome wheats, in case of bagged spikes, in certain combinations from 37.7% (*T. durum arraseita* $\times$ *T. dicoccoides* ps. *jordanicum*) to 81.8% (*T. dicoccum atratum* $\times$ *T. dicoccoides spontaneo-nigrum*) of the flowers set seed, on the average approximately 70%. In hybrids from crosses with 42-chromosome species fertility was considerably lowered, 21.3% of the flowers setting seed in the hybrids pr. *judaicum* $\times$ *T. vulgare caesium*, 8.1% in the hybrids pr. *judaicum* $\times$ *T. vulgare erythrospermum*, only 1.9% in the hybrids pr. *horanum* $\times$ *T. vulgare*

caesium and 0.88% in the hybrids pr. *horanum* × *T. vulgare erythrospermum*; 9.5 and 8.0%, respectively, in the hybrids pr. *horanum* × *T. spelta* and pr. *horanum* × *T. macha*.

Behaviour of Hybrids from Crosses between *T. armeniacum* and the 28-Chromosome Group of Wheats

Hybrid combination	Number of plants	Self-pollination		Backcross		Open pollination	
		number of flowers	number of kernels	number of flowers	number of kernels	number of flowers	number of kernels
T. armeniacum:							
× *T. dicoccum georgicum* .	48	1 461	—	1 490	8	13 500	6
× *T. dicoccum atratum* . .	13	—	—	79	1	1 920	1
× *T. persicum fuliginosum* .	42	2 682	—	731	1	8 150	—
× *T. durum hordeiforme* 010	17	55	—	1 260	5	2 100	—
× *T. dicoccoides* ps. *jordanicum*	19	1 031	—	—	—	5 720	1

Of the morphological peculiarities of F_1 hybrids with ssp. *armeniacum* may be noted: abortive generative organs (anthers) in the F_1 from crosses with wild einkorns, a species morphologically closest to ssp. *armeniacum*; reduced, albino leaf blades in some of the hybrids with Georgian *T. dicoccum*, and dwarf, narrow-leaved plants with abortive generative organs in others. The nature of the latter hybrid combination is, apparently, due to peculiar interactions of the genes of the parental forms. Plants of the other hybrid combinations were morphologically normal (Fig. 3). We did not obtain hybrids between ssp. *armeniacum* and either *T. monococcum* or *T. spelta*, since the hybrid seedlings of the first combination died at early stages of development and the kernels from the second combination did not germinate.

Fig. 3. Spikes of *T. armeniacum* (left), of *T. dicoccoides* ps. *jordanicum* (right), and of the F_1 hybrid between them (center).

In order to elucidate the peculiar behaviour of hybrids from crosses with ssp. *armeniacum*, a study of meiosis in the hybrids was undertaken. We shall describe here in its general outlines meiosis in the hybrids from crosses between ssp. *armeniacum* and the durum wheats, *T. dicoccoides* var. *pseudojordanicum*, *T. dicoccum georgicum*, and *T. durum hordeiforme* 010. At metaphase in these hybrids—instead of there usually being 14 close bivalents and never more that 4 univalents, as described by a number of investigators for hybrids between 28-chromosome wheat and *T. dicoccoides* Körn. ([6],[7])—we found from 2 to 10—12 (perhaps even more) univalents. Most of the bivalents were of a loose type, in which the partners were united

end to end; however, in the combinations with *T. dicoccoides* (Fig. 4) and *T. durum* we found as many as 5 close bivalents (usually 2—3) and in the combination with *T. dicoccum georgicum* as many as 7 (usually 4 — 5). The number of trivalents and quadrivalents ranged from 0 to 3—4 per cell (usually 1—2). Occasionally there were found groups of more than four chromosomes. At first anaphase, after separation of the bivalents (chromatin-bridges are often formed at their separation), the univalents assemble on the equator and split, the number of splitting univalents reaching as many as 7—9 (usually 2—5). Some of the univalents are not included in the daughter nuclei, but form micronuclei, the latter numbering as many as 4 per cell, but usually only 1 or 2. At second anaphase there are also found chromatin-bridges and lagging chromosomes, as a result of which tetrads are formed with micronuclei and microcytes.

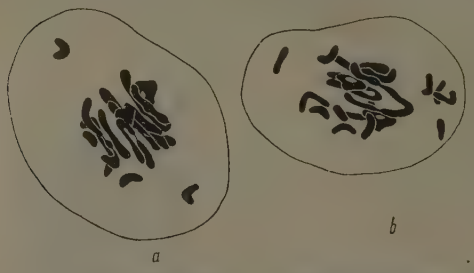

Fig. 4. First metaphases in pollen mother-cells of the hybrid *T. armeniacum*×*T. dicoccoides* ps. *jordanicum*: *a*—2III + 9II + 4I; *b*—1VI + + 2III + 4II + 10I.

Despite the numerous irregularities at meiosis, it can hardly be imagined that they alone are responsible for the complete sterility of the hybrids, all the more since we found dyads without micronuclei and a 14—14 chromosome distribution at first anaphase. Hence we are inclined to believe that the cause is the disturbance of the genic balance in the hybrid gametes, it being impossible to substitute chromosomes of other species for all the chromosomes of ssp. *armeniacum* is due to the divergence of genoms during the process of evolution. The latter, of course, also causes irregularities at meiosis.

All the above facts, showing how Armenian wild emmers are geographically, botanico-morphologically and genetically set apart not only from cultivated 28-chromosome wheats, but also from the Syrian-Palestinian subspecies, constitute sufficient ground for giving them the rank of a separate species, *Triticum armeniacum* (Jakubz.) sp. n. (retaining the old name given by Jakubziner to the subspecies). It is impossible to state definitely what the genomic composition of *T. armeniacum* is, until the cytological analysis of all the hybrid combinations has been completed. It may prove necessary to make out of *T. armeniacum* a special group of durum wheats, as Kihara(6) did with *T. Timopheevi* Zhuk.

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ZOOLOGY

ON SOME RELICT ELEMENTS AND COLEOPTEROFAUNA OF THE MIDDLE DONETZ REGION

By K. V. ARNOLDI and L. V. ARNOLDI

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Entomological research started by the authors in 1917 in the region of the Donetz biological station near Zmiev, Kharkov province, has brought to light entomofauna of peculiar and complex composition, whereupon special attention was given to entomological studies in the region of the Middle Donetz. During recent years there has been opportunity to widen the scope of entomological observations over the Slaviansk and neighbouring regions in the Donetz and Kharkov provinces. As a result of these investigations, faunal lists have been made up, comprising rather varied species which seem mutually to exclude one another and to be hardly compatible at one geographic point. Inasmuch as a correct explanation and differentiation of the intricate faunal complex are possible only upon elucidation of ecological features of its component parts readily observable in separate biocoenoses, and on consideration of the history of the landscapes under investigation, the necessity for a more comprehensive study became apparent. Increasing stress was laid rather on biocoenology and history of coenoses than on faunistic works. In conformity therewith, were introduced quantitative methods of statistics of population and of elements of microclimatic studies, which constitute the principal object of the work now under way.

The area under investigation is part of the landscape zone of the southern forest-steppe as it borders on the steppe. The Donetz valley, thrust deeply into the Donetz upland at the mid-height of the spurs, exhibits diversified features of scenery. The high hilly right bank is clothed with oak-woods, mostly thinned out to a considerable extent, and only on places wonderfully preserved as patches of century-old dense forests. Occasionally there are met rocky and ridge-like outcrops of chalk, covered in the vicinity of Sviatogorsk with chalky pine-wood. The highly developed Donetz valley is covered by meadows and overflow woodland; the second terrace displays extremely well developed sands, occasionally accompanied by salt-marshes and in places covered with heavy conifer forests. The left bank of Donetz is steppe-land descending toward the valley with more gentle slopes.

A number of groups of insects have been studied by us, though herein merely tough-winged will be mentioned to characterize the relict type of the biocoenoses and of some essential features of the entomofauna of the aforesaid region.

Against the background of the forest-steppe and steppe landscape in eastern Ukraine are sharply outlined original and clear-cut natural complexes of the above-mentioned oak-woods, chalks with pine-trees and hilly sands. At the present time these uneven-aged complexes are at different stages of extinction and while oak-woods and sands are to a certain degree confined to European or Asiatic regions where such forest type-groups are still florishing, mountainous pine-woods mark detached and isolated islands. Oak-woods on the left shore bear characteristic features of heavy forest relict coenoses; their typical components are restricted at the present time to a milder and more humid climate and are widespread now chiefly in the south-western and central parts of Western Europe and in Northern Caucasus. The age of these elements dates back at least to the Interglacial Epoch. The forests thus described are characterized by strongly developed canopies of dense crowns, scarce underwood and well developed forest litter. The following *Coleoptera* should be recognized there as quite typical among the dwellers of the tree—*Rhysodes sulcatus* F., *Colydium elongatum* F., *Prostomis mandibularis* F., *Ptilinus fissicollis* Rt., *Nosodendron fasciculare* Ol., *Leiestes seminigra* Gyll., *Platypus cylindrus* L., *Rhopalopus hungaricus* Hbst., *Stenocorus quercus* Goze, *Bradybates subfasciatus* Gerst., *Aesalus scrabaeoides* Panz. and *Ochodaeus chrysomeloides* Schrnk.; in the forest litter thrive—*Hedobia imperialis* L., *Urometopus* sp., *Barypithes* sp., *Acalles* sp., as well as predators *Platysma* (Abax) *atrum lukjanovitschi* Lutshn. and *Stomis pumicatus* Panz. The majority of these species are very cheracteristic of broad-leaved forests of the south-eastern part of Western Europe, while in our contry they are thrust far eastward to the foreground of their ranges and in most cases have up till now been registered only near the western border of the USSR.

The chalks in the Sviatogorsk region form a peculiar complex of mountainous pine-woods: among the chalky pine-wood, presenting a thinned plantation, there is a splendid diversified underwood with a prevalence of sumac (*Rhus*)—*Cotinus Coggygria*; on the southern slopes there are scattered brush patches with typical rocky cretaceous vegetation prevailing. Even from outer appearance the above complex bears strong resemblance with some langscapes of the Mediterranean type, for example, the forests on cretaceous limestones at the northern Crimean foothills; by the composition of the population it seems to be descendent from warmer climatic conditions, especially since many of its characteristic representatives are at the present time decidedly moving towards the Mediterranean. In pines are thriving buprestids—*Anthaxia sepulchralis* F. and *A. godeti* Cast. et Gory (first revelation of its kind in the European part of the USSR); further, as characteristic here may be mentioned *Anthaxia olympica* Kies., *Timarcha coriaria* Laich., *Chilotoma erythrostoma* Fld., *Phyllobrotica elegans* Kr., *Foucartia squamulata* Hbst., on sumacs in abound—*Labidostomis humeralis* F., on *Vincentoxicum*—*Chrysochus asclepiadeus* Pall., on *Centaurea*—assemblages of *Allecula morio* F. and others. Some of the aforementioned species occur sometimes without the Cretaceous complex, but within they are especially numerous and characteristic.

A sharply outlined complex present hilly sands of the second terrace of the left shore, partly open, partly sodded or artificially fenced in by plantations of pines and willows (*Salicaceae*). The sand complex in this particular region is undoubtedly not pressed toward extinction now, though at a certain post-glacial time it attained appreciably greater development, which is borne out, by the way, by many characteristic species, distributed in our zone sporadically and scattered in detached ranges. To open sands are confined: *Corsyra fusula* F.-W., *Hypocaccus metallicus* Hbst., *H. formosus* Rchdt.

(in litt.), *Sphenoptera basalis* Mor., *Sph. substriata* Kryn., *Cylindromorphus pyrethri* Stierl., *Anatolica eremita* Stev., *Tentyria nomas* Pall., *Pimelia subglobosa* Pall., *Gonocephalum pygmaeum* Stev., *Leichenum pictum* F., *Notoxys elongata* Laf., *Chrysomela cinctipennis* Har., *Cyphocleonus achates* Gyll., *Mecaspis marginicollis* Gyll., *Pleurocleonus sollicitus* Gyll., *Bothynoderes foveicollis* Gebl., *Lixus vibex* Pall., *L. punctiventris* Boh., *L. punctirostris* Boh., *Cneorrhinus albinus* Boh., *Myorrhinus albolineatus* F., *Neobaris duplicata* Boh., *Pachytychius sparsutus* Ol., *Ceratophyus polyceros* Pall., *Psammobius sulcicollis* Ill., *Ps. laevipennis* Costa, *Anoxia pilosa* F. and *Monotropus nordmanni* Blanch. Though these species are extremely characteristic of our sands, some of theme are ecologically more widely spread in the main zone of their habitat, in the south-east.

Some of the other complexes in the described region have no less typical representatives, and being that they have no pronounced relict character we shall quote no more than a few examples of these. For the salt-marshes are typical *Cicindela lunulata* F., *Chlaenius spoliatus longipennis* Mot., *Broscus cephalotes semistriatus* F.-W., *Clivina ypsilon* Dej., weevils (*Curculonidae*) *Baris spitzii* Hochh., *Erycus petax* Sahlb. and others. Among those dwelling in the river banks are of interest *Bembidium menetriesi* Kol., *Drypta dentata* Rossi, *Drasterius bimaculatus* Rossi, *Potamophilus acuminatus* F., in overflow forests—*Melanophila decastigma* F., *Cossonus* sp., *Rhyncolus sp.* In the conifer forests a great development of *Ergates faber* L. is observed and for the first time in the USSR *Chrysobothris igniventris* Rt. has been registered. Of the steppe-land species are typical for our region: *Carabus estreicheri* F.-W., *Zabrus blapoides* Creutz., *Hypocacculus amoenus* Fr., *Anthaxia rossica* Dan., *Steropes caspius* Stev., *Asida lutosa* Sol., *Stenodera caucasica* Pall., species *Halosium*, *Lydus algiricus* L., *Dorcadion sericatum* Kryn., *Plagionotus floralis* Pall., *Cryptocephalus apicalis* Gelb., *Cr. laevicollis* Gelb., *Pachybrachis probus* Ws., *P. fimbriolatus* Suffr., *Pleurocleonus quadrivittatus* Zubk., *Eusomus beckeri* Tourn., *E. ovulum* F., *Liparus tenebrioides* Pall., *Strophosomus albolineatus* Sdl., *Scarabaeus sacer* L., *Gymnopleurus mopsus* Pall., *Lethrus apterus* Lxm., *Sisyphus boschnjaki* F.-W., *Pentodon idiota* Hbst., *Potosia hungarica* Hbst. There have been single finds of *Prosodes obtusa* F., *Hoplia zaitzevi* Jacobs. and some others.

Among the enumerated species many reach in the region under investigation the limits of their ranges, namely the northern, eastern or western. In this relation special notice should be taken of the following species, whose occurrence in the Donetz region is evidence of a considerable extension of their ranges hitherto known and in some cases has been established for the first time in the USSR. Here may be drawn the eastern border for the European part of the USSR in regard to species (besides those referred to the forest relicts enumerated above) which are common in the southern and central parts of Western Europe: *Anthaxia salicis* F., *A. podolica* Mannh., *Coroebus undatus* L. (for the first time in the USSR), *Balaninus venosus* Grav., *B. pellitus* Boh., *Apion astragali* Payk., *Sermylassa halensis* L., *Mecaspis alternans* Hbts. The following chiefly Mediterranian species are here approaching the northern limits of their ranges (in addition to those mentioned in the lists of relict coenoses): *Pachylister inaequalis* Ol., *Saprinus semipunctatus* F., *Hister planulus* Men., *Elater sinuatus* Germ. (for the first time in the European part of the USSR), *Acmaeodera degener* Scop. (as above), *Anthaxia aurulenta* F., *Capnodis tenebrionis* F., *Stigmatium mutillarium* F., *Gasrallus laevigatus* Ol. (for the first time in the European part of the USSR), *Oligomerus retowskyi* Schielsk., *O. brunneus* Ol., *Baris concinna* Boh., *B. atricolor* Boh., *B. scolopacea* Germ., *Larinus minutus* Gyll., *Mesagroicus*

sp. (steppe near Nyrkov, northern Donbass), *Cerambyx cerdo* L., *Trox cadaverinus* Ill.

Besides, as of rare and interesting finds spec al mention should be made of: *Anthaxia türki* Ganglb., *Larinus ruber* Mot., and of some relatively rare species which have been encountered in definite environments in prodigious numbers: on old pear trees—*Purpuricenus kaehleri* L., *Rhynchites giganteus* Kryn., *Gnorimus variabilis* L., on lindens—*Lampra rutilans* L., *Dicerca alni* F.-W. and *Saperda 8-punctata* Scop.

In this brief paper the ecological and microclimatic aspects of the investigation have not been touched upon as they shall receive special attention in the main work.

In conclusion I am satisfied to mention the following collaborators who have participated in the determination and verification of *Coleoptera*: F. K. Lukianovich, S. I. Medvedev, D. A. Ogloblin, E. M. Stepanov and others.

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DEVELOPMENT MECHANICS

ON THE QUESTION WHETHER OR NOT STRUCTURE AND FORM VARIATION OF PLUMAGE FOLLOWING THYROIDECTOMY MAY BE REGARDED AS AN INDEX OF ITS MASCULINIZATION

By A. A. WOITKEWITCH

(Communicated by I. I. Schmalhausen, Member of the Academy, 29. X. 1938)

At present considerable material has been accumulated concerning the influence of the sexual gland on feather-formation in birds. Experiments on fowl with dimorphic plumage have shown that the plumage in castrated birds of both sexes scarcely differs from that of normal males. The development of a female plumage is determined by the hormone of the ovary. The problem as to the influence of the thyroid gland upon the development of colour and structure characters of the plumage has as yet not been definitely solved. It is assumed that for the formation of the black pigment there is necessary a definite concentration of the hormone of the thyroid gland, while an excess of the hormone causes depigmentation and structural changes of the feather. Križenecky([4]), Greenwood and Blyth([3]) consider that the feathers of thyroidized cocks resemble as to colour and structure to those of the hen. According to the experiments of Crew([2]), Greenwood and Blyth([3]) and Schwartz([6]), the feathers of thyroidectomized hens are rather shifted towards the cock-type. These data led the above authors to the conclusion that sexual dimorphism of the plumage in birds is connected with a different function of the thyroid gland in the two sexes, this gland being activated to a different degree by testes and ovaries respectively.

To support the validity of this assumption it is necessary to show, first, that the intensity of the thyroid gland function is different in males and females, and, secondly, that thyroidectomized females actually develop male plumage, and vice versa. However, according to Chaudhuri's data([1]), thyroid glands in fowl display no sexual variation as to iodine content. Larionov([5]), while comparing the biological activity of the thyroid gland, did neither succeed in discovering any noticeable variation in birds of both sexes. The author was successful to show that the difference in the function of the thyroid glands of male and female pigeons takes place only during ovulation. M. Zawadowsky([7]) believes that the plumage of thyroidized cocks, pheasants and pea-cocks displays as to structure and colouring a merely external likeness with the female attire. One arrives at the same conclusion in examining the photographs of feathers of thyroidized hens([3]). As to the condition of the plumage in thyroidectomized birds, further investigation seems to be necessary, since there arises a question, whether changes in the structure and shape of the feather in females are real indices of

their masculinization, whereas in males they are indices of supermasculinization, as stated, among others, by Schwartz(6). The solution of this problem can be approached by comparing variations of the plumage in thyroidectomized dimorphic and monomorphic birds.

If the facts are as stated by Križenecky and others, i. e., characters of dimorphism of the plumage depend on the function of the thyroid gland, then its extirpation should cause corresponding changes only in those birds which possess a dimorphic plumage. If, on the contrary, such changes appear in the developing plumage of birds which are not dimorphic, we are justified to assume that changes in the plumage, setting in after thyroidectomy, are due to a general action of the thyroid hormone on feather-formation rather than to its specific property. The experiments were performed on a number of species of birds, the latter being classed among the three following groups:

1. Birds with distinct differences in the plumage, which may be changed by castration or by introducing sexual hormones (fowl of the Italian partridge breed, Rouen ducks).

2. Birds with distinct differences of the plumage in both sexes, in which no changes are brought about neither by castration, nor by introducing sexual hormones (*Passeriformes:* finches, crossbills, sparrows).

Fig. 1. The two feathers on the left—primaries of a lark, on the right—those of a cross-bill. *a*—control, *b*—experiment: *c* — experiment, *d* — control.

3. Birds, males and females, possessing a similar plumage, affected neither by castration, nor by sexual hormones (pigeons, other species of *Passeriformes:* sky-larks and daws)*.

It occurred that thyroidectomy, when practised on birds of all the above species, gives similar results as to variation of structure and form of the plumage, irrespective of the group the given bird belongs within. The authors who considered that in hens developing feathers assumed after thyroidectomy a male character, were led to this conclusion by the fact that the vanes of the feathers on the neck and the sacrum, as well as of other small feathers, were in these birds thinning out, and in normal cocks they are narrow and rather pointed. Our observations showed that complete thyroidectomy is considerably inhibiting the growth of new feathers; the latter grow narrower (on some pteriliae even shorter) with rather pointed ends. When plucked beyond the period of moulting, they sometimes fail to develop at all on the pteriliae of body and neck. The development of large feathers (primaries and tails) takes place nearly always, but in their form and structure the new feathers greatly differ from normal ones. Fig. 1 shows the feathers of a cross-bill and a lark. The table contains the results of measurements of vanes of primaries in thyroidectomized and normal birds.

Thinning out of vanes is well pronounced in all cases. This phenomenon can, however, scarcely be considered as an index of masculinization, since, as we have already mentioned, it is taking place after the extirpation of the thyroid gland irrespective of the group the given bird belongs to, and even on those feathers which in males bearing a well expressed male plumage never thin out in case of normal development. Alongside of changes occurring

* Throughout the experiments exclusively adult birds were made use of.

Size of Vanes (Primaries No 9 and 10) of Thyroidectomized Birds and Controls of Various Species

Group	Species	Length of feather		Width of feather	
		Control	Experiment	Control	Experiment
1	Fowl	147.0	107.4	32.5	17.3
	Ducks	112.6	116.0	24.0	20.0
2	*Loxia curvirostra*	49.0	46.5	9.7	4.8
	Fringilla collebs	51.5	48.0	9.5	5.5
	Passer domesticus	50.5	48.4	11.2	6.0
3	Pigeons	98.3	89.0	28.3	14.5
	Coloeus monedula	108.0	97.0	27.0	19.0
	Alauda arvensis	56.0	46.5	14.5	6.3

in the colouring of the plumage, the thinning out of vanes takes place on other pteriliae of experimental birds. Thus, for instance, in thyroidectomi-

Fig. 2. Breast feathers: *a*—normal cock, *b*—normal hen; *c*—thyroidectomized hen.

zed cocks and hens the vanes of breast feathers thin out, while in normal birds they are rounded in both sexes and differ only in size and colour. Fig. 2 shows that the feathers of a thyroidectomized hen are strongly thinned out and do not resemble those of normal birds. By the way, it should be noted that in thyroidectomized cocks of the Italian partridge breed we observed the development of brown breast feathers similar to those of a hen. After they had been given thyroidine, the normal black pigment, as well as the normal structure, were restored. Thus, in our experiments thyroidectomy caused a partial feminization of the male plumage. These data require, however, further investigation.

The above observations on the development of the plumage in thyroidectomized birds show that the conclusion as to the feminizing effect of the hormone of the thyroid gland lacks experimental evidence. At the same time it is beyond any doubt that both the hormone of the thyroid gland and that of the sexual glands play an important rôle in the formation of the plumage.

The feather «anlage» as a rule possesses the potency to produce several types of feathers. Being influenced by the gonads, this potency is realized in a definite form. The potency may be realized provided there exist all conditions necessary for the normal growth of the plumage, the presence of the thyroid hormone belonging to those conditions. The rate of the growth of the feather, the formation of its structure and its definitive size are chiefly dependent on the hormone of the thyroid gland. The latter forms the background against which appears the mosaic of all the characters induced by other factors including the sexual gland hormones.

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ENTWICKLUNGSMECHANIK

EXPLANTATIONSVERSUCHE VON EXTREMITÄTSANLAGEN

Von L. W. POLEŽAJEW

(Vorgelegt von N. W. Nassonov, Mitglied der Akademie, d. 22. X. 1938)

I. Einleitung. Welches ist das Minimum der für die Entwicklung einer Extremitätsanlage erforderlichen Faktoren?

In Schwanzknospenstadium des Embryons der Amphibien ist die Anlage der vorderen Extremitäten an der Seite, hinter dem Kiemen lokalisiert, ventral vom Pronephros. Sie besteht aus Somatopleura und Epithel. Allmählich sondern sich aus der Somatopleura Mesenchymzellen ab, die sich auf dem Epithel lagern und eine linsenförmige Anlage bilden. In diesem Stadium tritt zwischen Epithel und Mesoderm deutlich die Basalmembran hervor, auch beginnt die ganze Anlage sich zu innervieren. Darauf fängt der Umfang der Extremitätsanlage an zuzunehmen, die Skelettanlagen treten hervor, und schliesslich zeigen sich die Muskelelemente.

Bei Verpflanzungen im Schwanzknospenstadium hat die Extremitätsanlage die Fähigkeit zur Selbstdifferenzierung [(1),(2)u. viele andere]. Die Extremitäten entwickeln sich, wenn in diesem oder einem früheren Stadium der Pronephros(1), und das ganze Entoderm der Neirula(4) entfernt wird, augenscheinlich auch bei Denervation [(5) u. andere].

II. Material und Methoden. Bis zum heutigen Tag wurden Explantationsversuche nur an Vogelembryonen vorgenommen(11). In der vorliegenden Arbeit dienten als Versuchsmaterial Keime des *Triton taeniatus*, dessen vordere Extremitäten sich ausserordentlich schnell entwickeln. Die Keime wurden in Holtfreterscher Salzlösung(7) bei voller Sterilisation im Stadium der Schwanzknospe und der linsenförmigen Extremitätsanlage explantiert. Die Explantationsdauer betrug durchschnittlich 8—9, höchstens 13 Tage. Die Explantate wurden in verschiedenen Entwicklungsstadien fixiert.

III. Experimentaler Teil. 1. Explantation der Seite. Im Schwanzknospenstadium wurde das Seitenmaterial explantiert, das eine oder auch beide Anlagen der vorderen Extremitäten enthielt. Die Explantate wurden mit oder auch ohne Pronephros genommen.

Das ausgeschnittene Stück zog sich stark zusammen und bildete ein unregelmässiges Klümpchen. Sodann wuchsen dessen Ränder zusammen, und es verwandelte sich allmählich im Laufe von 1—2—3 Tagen in einen beinahe durchsichtigen, innen hohlen, kugelförmigen Körper. Danach traten in demselben keine Veränderungen mehr auf, bis auf ein unbedeutendes Zunehmen des Umfangs. Bei keinem einzigen von 44 angestellten Versuchen entwickelte sich die Extremität. Histologische Untersuchungen ergaben, dass

das Explantat aus Epithel und einem dünnen mesodermalen Bezug (Somato- und Splanchnopleura) besteht. Im Inneren dieser Umhüllung befindet sich eine unbedeutende Menge unregelmässig verteilter Mesenchymzellen und Fasern, zwischen denen in vielen Fällen Pronephros vorkommt. Derselbe ist meistens kugelförmig, hat dicke Wände und eine kleine Innenhöhlung. Ausserdem trifft man im Mesenchym häufig Entodermklümpchen.

Gegen Ende des Versuchs bildeten sich an den normalen Kontrollkeimen Extremitäten mit drei Zehen und einem gut entwickelten Knorpelskelett. Die Vorniere war gut entwickelt und bestand aus unzähligen Kanälchen mit dünnen Wänden und grossen Höhlen.

2. Explantation der Seite und des Entoderms. Die Ergebnisse der vorgehenden Versuche konnten dadurch bedingt sein, dass die Explantate durch keine anderen, nicht ins Explantat aufgenommenen Teile des Keims beeinflusst wurden; oder auch dadurch, dass der Spannungsgrad der Gewebe der Extremitätsanlage während der Explantation stark verändert ist. Bei normaler Entwicklung sind diese Gewebe stark auf die Oberfläche des Keimkörpers gespannt; bei der Explantation dagegen sind sie längere Zeit (1—3 Tage lang) stark zusammengepresst. Zwecks näherer Erklärung dieses Faktors wurde folgender Versuch angestellt.

Der Bauchteil eines im Stadium der Schwanzknospe und der linsenförmigen Anlage befindlichen Keimes wurde isoliert. Dieser Teil bestand aus Seiten- und Bauchepithel und Mesoderm, die beide auf das Epithel gespannt waren. Wie oben gesagt, hat Mangold[4] bewiesen, dass die Extremitäten des Tritons sich nach voller Entfernung des Entoderms im Neurulastadium gut entwickeln. So war also das Entoderm in den vorliegenden Versuchen nur als mechanischer Faktor ausgenutzt. Im ganzen wurden 92 Versuche angestellt. In den meisten Fällen blieb das Entoderm unverletzt und die Extremitätsanlagen waren stark darauf gespannt, wie in normalem Zustand. In diesen Fällen erschienen die Extremitäten an ihren normalen Stellen und entwickelten sich weiter bis zur Anlage der 2—3 Zehen inklusiv. Die Kontrollextremitäten der normalen Keime entwickelten sich etwas rascher, als die Untersuchungskeime. Der Entwicklungsverlauf der Extremitäten bei den Explantaten unterschied sich kaum von dem der normalen und machte dieselben Stadien durch. In morphologischer Hinsicht liess sich jedoch wohl ein Unterschied feststellen. Die Extremitäten, die sich bei Explantation im Stadium der Schwanzknospe entwickelten, enthielten keine Pigmentzellen, während sie bei Explantation in späteren Stadien welche enthielten. Eine Erklärung dafür haben die Arbeiten Ravens[9,10] und Duschanes[3] gegeben, die erwiesen haben, dass die Pigmentzellen durch Migration des Materials der Ganglionarleiste entstehen. Ausserdem lässt sich in den Extremitäten der Explantaten öfters eine atypische Verteilung des Mesenchyms beobachten: am Epithel und an der Basis der Anlage ist es stark gelockert, wogegen es bei normaler Entwicklung in der ganzen Extremitätsanlage stark konzentriert ist. Auf Rechnung dieser Gelockertkeit des Mesenchyms wächst der Umfang der Extremitäten bei den Explantaten bedeutend. Anlage, Entwicklung und Verknorpelung des Skeletts gehen im Versuch, wie in der Kontrolle auf gleiche Weise vor sich.

Waren bei der Operation die Anlagen lädiert, so entwickelten sich in der Folge, wenn auch nicht immer, atypische Extremitäten. In den Fällen aber, wo gar keine Entwicklung stattfand, bestand die Lädierung in folgendem: das Entoderm quoll hervor, und die Bestandteile der Anlage schrumpften stark zusammen. In diesen Fällen also, ebenso wie in der vorhergehenden Versuchsserie, wo man das Seitenmaterial ohne Entoderm explantierte, entwickelten sich die Extremitäten infolge starker Zusammenpressung des Explantats gar nicht.

Interessant ist die Tatsache, dass die Extremitäten der Explantate aus einem späteren Stadium (linsenförmige Extremitätsanlage) sich schlechter entwickeln, als die Extremitätsanlagen aus einem früheren Stadium (Schwanzknospe).

Die Explantate bestanden aus Epithel, Mesodermalbezug und basaler Membran. Wenn das Explantat einem späteren Stadium angehörte, befanden sich unter dem Epithel auch Pigmentzellen. Im Inneren enthielten die Explantate Entoderm, Pronephros und häufig auch Herzanlagen. Diese letzteren waren hohl und pulsierten. Der Entoderm-Dotter wurde allmählich resorbiert, aber bedeutend langsamer, als bei Kontrollkeimen. Die Resorbierung des Dotters sowie die Differenzierung des Entoderms verliefen bedeutend schneller und besser bei den Explantaten, die einem späteren Stadium angehörten. Über die Entwicklung des Entoderms soll in einer besonderen Arbeit berichtet werden. Die Vornieren differenzierten sich in eine Reihe kleiner Kanälchen mit dünnen Wänden.

3. Explantation der Seite, des Entoderms und der Axialorgane. Diese Versuchsserie wurde vorgenommen um die Wirkung der Explantation als solcher auf die Entwicklung der Extremitäten zu prüfen. Einem Keim im Stadium der Schwanzknospe wurde mittels einiger Querschnitte der ganze Teil zwischen dem 3 und dem 6 Somiten isoliert. Die Wunden verheilten rasch. Das Explantat schwoll allmählich auf, wie eine Blase. Die Extremitäten entwickelten sich ungefähr ebenso, wie in der zweiten Versuchsserie, aber sie enthielten immer Pigmentzellen. Das Explantat enthielt eine Nervenröhre, eine Chorde und stark gelockerte Myotome. Das Explantat war innerviert und zuckte. Das Entoderm differenziert sich gut zu einem Stück dünner Darmröhre. Am Rückenteil des Explantats entwickelte sich die Schwanzflosse, die aus Epithel und lockerem gallertartigem Gewebe bestand.

Aus dieser Versuchsserie können wir den Schluss ziehen, dass die Extremitäten sich bei Explantation ganz gleich entwickeln, gleichviel ob die Axialorgane: Myotome, Chorden und Nervenröhren anwesend sind oder nicht. 2-te Schlussfolgerung: die Extremitäten der Explantate entwickeln sich bei An- oder Abwesenheit der Axialorgane ganz ebenso, aber schwächer, als bei den Kontrollkeimen. Dieser Umstand kommt auf Rechnung der Explantationsoperation an dem Teil des Keims, der die Extremitätsanlage enthält.

4. Anhang. Bei Isolierung des Bauchteils des Keimkörpers blieben folgende Teile zurück: der Kopf, die Axialorgane des Rückens und die Schwanzknospe. Diese «Kopfrückenteile» wurden auch in Salzlösung gelegt. Die klaffende Wunde heilte bald zu, und diese Teile begannen sich zu entwickeln. Sie entwickelten sich synchronistisch mit den normalen Keimen. Alle Organe des Kopfes entwickelten sich in ihnen: die Augen mit ihren Linsen, die Haftfaden, die Nase, das Gehirn, die Axialorgane bestehend aus Chorde, Somiten, Nervenröhre; über denselben zog sich eine gute Rückenflosse, und hinter denselben entwickelte sich ein grosser Schwanz. Die Keime waren dicht mit Pigmentzellen besät und bewegten sich gut, schwammen im Wasser. Ihnen fehlte nur Bauch mit den Entodermalorganen, dem Herzen, dem Pronephros und den Extremitäten. Am auffälligsten war bei diesen «Kopfrückenkeimen» die mangelhafte Entwicklung der Kieme. Während die Kontrollkeime starke, gut verzweigte Kieme aufwiesen, ragten bei den anderen nur drei dünne Endchen hervor. Die mangelhafte Entwicklung der Kieme kann als Folge der fehlenden Blutzirkulation und des fehlenden Atmens betrachtet werden. Folglich übt die Funktion des Atmens eine bedeutende Wirkung auf die Morphogenesis der äusseren Kiemen aus [vergl. die Angaben Maschkowzew(8)].

IV. Zusammenfassung. 1. Die Extremitätsanlagen der Tritonenkeime wurden in Salzlösung explantiert. Dabei entwickelten sich Extre-

mitäten, die die Anlagen von 2—3 Zehen, Mesenchym, ein Knorpelskelett und Epithel mit basaler Membran aufwiesen. Wenn die Explantation in einem früheren Stadium, als das Schwanzknospenstadium, vorgenommen wurde, entwickelten sich in den Extremitäten Pigmentzellen.

2. Für die Entwicklung der Extremitäten bei Explantation in Salzlösung ist die Anwesenheit des Epithels und Mesoderms in ihren Anlagen durchaus notwendig. Jedoch geht diese Entwicklung nur bei starker Dehnung des Explantationsmaterials vor sich. Die Gesamtheit der hier aufgezählten Faktoren ergibt folglich das Minimum der für die Entwicklung der Extremitäten erforderlichen Faktoren. Pigmentzellen, Korium, Auswüchse der Myotome, Nerven, normale Blutversorgung—das alles sind Faktoren, die aus dem Entwicklungsprozess der Extremitäten des Tritons ausgeschlossen werden können, ohne dass die typisch charakteristischen Merkmale der Extremitäten Abbruch erleiden.

3. Es sind Angaben über die Entwicklung explantierter Anlagen entodermaler und auch einiger mesodermaler Tritonkeimorgane erhalten.

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ENTWICKLUNGSMECHANIK

ÜBER DIE INDUKTIONSFAKTOREN DER ANFANGSSTADIEN DER EXTREMITÄTENBILDUNG BEI DEN AMPHIBIEN

Von L. W. POLEŽAJEW

(Vorgelegt von N. W. Nassonov, Mitglied der Akademie, d. 22. X. 1938)

I. Einleitung. Balinsky([1,2]) hat bewiesen, dass bei einem Tritonkeim durch Induktion eine Ergänzungsextremität hervorgerufen werden kann. Die Extremität kann nur aus dem Material des Seitengebietes zwischen der hinteren und vorderen Extremität induziert werden. Filatow([4]) beweist, dass der Determinationsprozess der Extremität bei Induktion dieselben Stadien als bei normaler Entwicklung durchmacht: entstehende Verbindung von Epithel und Mesenchym; Entwicklung der linsenförmigen Anlage, sowie auch die ferneren Stadien.

Welches ist das Minimum der für die Induktion einer Extremität erforderlichen Fartoren? Für die Entwicklung der Extremität aus ihrem präsumptiven Material sind Epithel und Mesoderm notwendig bei unbedingter mechanischer Dehnung derselben und beim Vorhandensein eines gewissen humoralen Mittels([5]). Bei der Induktion einer Extremität ist ausser diesen Faktoren noch ein gewisser Induktor notwendig (Ohrblase, Hypophise, Zelloidin, Nasenplakode u. a.). Aber auch diese gesamten Faktoren können sich für die Induktion der Extremität als ungenügend erweisen. Filatow([3,4]) nimmt an, dass für eine Extremitätsinduktion auch noch die Einwirkung eines spezifischen Faktors notwendig sei, der mit dem Gebiet zusammenhängt, in dem die Induktion hervorgerufen werden kann, d. h. im Gebiet der Seite. Die Anfangsstadien der Extremitätsbildung sind nicht spezifisch.

Es tauchen jetzt zwei Fragen auf:

1. Können die Anfangsstadien der Extremitätenentwicklung unter solchen Bedingungen induziert werden, wenn Seitenmaterial und Induktor vorhanden sind, aber jede Möglichkeit einer Einwirkung von Seiten eines andern etwaigen spezifischen, mit dem Gebiet der Seite in Verbindung stehenden Faktors ausgeschlossen ist?

2. Sollte es sich erweisen, dass diese Induktion unter den angegebenen Bedingungen möglich ist, würde wohl die entstandene Anlage fähig sein sich zu einer typischen Extremität zu entwickeln?

Die vorliegende Arbeit stellt sich zur Aufgabe die erste Frage zu beantworten.

II. Der experimentale Teil. Als Versuchsmaterial wurden Keime von *Triton taeniatus* genommen. Die Keime wurden in Salzlösung gehalten, die allmählich mit destilliertem Wasser verdünnt wurde. Die Operation wurde unter Sterilitätsbedingungen vorgenommen.

1. Transplantation des Seitenmaterials auf den Kopf eines andern Keims. a) Diese Versuchsgruppe diente einer andern Gruppe (b) derselben Serie als Kontrollgruppe. Die Transplantation wurde hier ohne Induktor (Nasenplakode) vorgenommen.

Im Stadium der Schwanzknospe (Stadium 29—30 nach Harrison) wurde dem Keim ein Quadratteilchen aus der Seite zwischen dem 6 und dem 10 Somiten herausgeschnitten. Dieser Teil bestand aus Epithel und Mesoderm (Somato- und Splanchopleura). Er wurde einem andern gleichalterigen Keim an Stelle eines entfernten Epithelteiles ins Kopfgebiet zwischen Auge und Ohrblase gepflanzt. Dabei liess man in 14 Fällen die Ohrblase des Rezipienten bleiben, und nur in 6 Fällen wurde sie entfernt. 14—17 Tagen nach der Operation konnte man keinen einzigen Fall feststellen, wo sich der Transplantat in etwas einem Extremitätskeim ähnliches ausgebildet hätte. Unter dem Epithel des Transplantats befand sich ein faseriges Netz aus Bindegewebe, in dem einzelne Mesenchymzellen unordentlich verstreut waren. Um dieselbe Zeit waren die normalen Vorderextremitäten dieser Keime gut entwickelt und besassen 3 Zehen und die Anlage der vierten. In einigen Fällen wurde unter denselben Bedingungen statt eines Teils aus dem Gebiet der Seite ein Teil aus dem Gebiet der präsumptiven Vorderextremität transplantiert. Aus diesem Transplantat entwickelte sich eine Extremität.

b) Die 2-te Gruppe dieser Vessuchsserie unterschied sich von der vorangehenden dadurch, dass das Seitenmaterial mit dem Induktor zusammen verpflanzt wurde. Die Operation wurde auf folgende Weise durchgeführt. Im Schwanzknospenstadium des Keims wurde demselben unter das Seitenepithel, im Gebiet zwischen dem 7 und dem 10 Somiten eine Nasenplakode verpflanzt, welche einem andern, gleichalterigen Keim entnommen war und als Induktor diente. 24 Stunden nach dieser Operation, als der Keim ins Stadium 33—35 (nach Harrison) überging, wurde eine zweite Operation vorgenommen. Aus dem Seitengebiet des Keims wurde ein Quadratstück ausgeschnitten, welches ausser Epithel und Mesoderm die zwischen denselben befindliche Nasenplakode enthielt. Das ausgeschnittene Stück wurde an die Stelle eines entfernten Stückes Epithel zwichen Auge und Ohrblase eines 3-ten Keims verpflanzt, der sich im Stadium 31—33 (nach Harrison) befand. Im ganzen wurden 17 derartige Doppeloperationen vorgenommen. Vier Keime wurden am 11. Tage, 12—am 21. Tage nach der 2. Operation fixiert; ein Keim kam um.

Um die Zeit der ersten Fixationsfrist waren die eigenen Vorderextremitäten der Keime gut entwickelt und hatten 3 lange Zehen. Unter dem transplantierten Epithel war eine kleine Wölbung zu sehen. Es erwies sich, dass in allen 4 Fällen die Induktion stattgefunden hatte. Neben der verpflanzten Nasenplakode war das Epithel ziemlich stark verdickt. Unter demselben hatte sich das Mesenchym gesammelt und zu einem Keim gruppiert. Es waren verschiedene Stadien von Mesenchymansammlungen unter dem Epithel zu sehen: zwei- und dreischichtige Ansammlungen noch undichten Mesenchyms und eine dichte, gewölbte, linsenförmige Anlage, die kaum von einer normalen Extremitätsanlage in demselben Stadium zu unterscheiden war. In einem Fall bildete sich neben der Nasenplakode ein knorpeliges Knötchen aus den Mesenchymzellen des Transplantats.

Um die zweite Fixationszeit ergaben sich 3 verschiedene Gruppen mit je verschiedenen Resultaten. In der ersten Gruppe war keine Induktion zu bemerken. Unter dem verdickten oder auch unverdickten Epithel des Transplantats befand sich die verpflanzte Nasenplakode und einzelne Mesenchymzellen, die unordentlich in dünnem Bindegewebe zerstreut lagen. In der 2. Gruppe liess die Induktion sich feststellen. Das verdickte Epithel bildete eine Anschwellung, unter der sich das Mesenchym gruppierte, in welchem

die Knorpel lagen. In der 3. Gruppe schienen die induzierten Anlagen einen Involutionsprozess durchgemacht zu haben. Das Epithel hatte seine konvexe Form beibehalten, hatte aber seine Verdickung verloren und war dünn geworden. Unter dem Epithel hatte sich das Mesenchym gelagert; es war locker geworden und zerstreute sich. Statt der festen linsenförmigen Anlage waren ziemlich dünn gelagerte Mesenchymzellen vorhanden. Sie hatten noch die für die Extremitätsanlage charakteristische Anordnung in konzentrische Kreisen. Jedoch war ein Teil des Mesenchyms desorientiert und stark zerstreut. In einzelnen Fällen war das Mesenchym im Zentrum verdichtet, aber an der Peripherie der Anlage stark zerstreut. Augenscheinlich handelte es sich in dieser Gruppe um induzierte und sich zerstreuende Anlagen.

2. Induktionsversuche an Extremitätsanlagen im Explantat. Als Versuchsmaterial wurden Keime im Stadium 32—33 oder 34—35 nach Harrison genommen. Die Operation wurde unter Narkose vollzogen (zur Salzsäure wurde Äther hinzugefügt). Unter das Seitenepithel der Anlage, ins Gebiet zwischen den Stellen der zukünftigen Anlagen der Vorder- und Hinterextremitäten, wurde eine Nasenplakode verpflanzt. Die Plakode wurde entweder autoplastisch oder homoplastisch einem gleichalterigen Keim verpflanzt. Eine Stunde nach dieser Operation wurde der Bauchseitenteil des Rezipienten isoliert, d. h. beide Seiten und der Bauch, die auf das Entoderm gespannt waren, wurden von den Axialorganen und vom Kopf getrennt. Auf diese Weise umschloss das Explantat nur die entodermischen Organe sowie die Vornieren, häufig auch die Herzanlage. Wie ich schon an anderer Stelle erwähnt habe[5], können diese Organe nicht als spezifische Entwicklungsfaktoren der Anlage angesehen werden. Darum könnte man annehmen, dass sie für die Induktion der Extremitätsanlagen auch keine spezifischen Faktoren seien.

Im ganzen wurden 28 Explantationsversuche vorgenommen. Die Explantate wurden gegen 12 Tage lang erzogen. Länger konnten sie nicht existieren: sie schwollen stark an, platzten und kamen um. Während dieser Zeit entwickelten sich bei den normalen Keimen grosse Vorderextremitäten mit 3 langen Zehen und die Anlagen der Hinterextremitäten. Bei den Explantaten bildeten sich die Anlagen der Vorderextremitäten in Gestalt langer Auswüchse, die den Anlagen der normalen Keime im Stadium 39—42 nach Harrison entsprachen. Die verpflanzte Nasenplakode war deutlich unter dem angespannten Seitenepithel zu sehen. In 11 Fällen von 28 fand die Induktion statt. Über der Plakode war das Seitenepithel lokal verdickt und bildete einen Auswuchs, neben dem sich das Mesenchym zu einer Anlage gruppierte. Es waren verschiedene Entwicklungsstadien von Anlagen vorhanden, angefangen von Stadium der gelockerten Somatopleura, aus der sich die Mesenchymzellen ausschieden und auf dem Epithel absetzten, bis zum Entwicklungsstadium der grossen linsenförmigen Knospe, die durchaus nicht von der normalen Extremitätenanlage zu unterscheiden war.

In den übrigen Fällen ist keine Induktion beobachtet worden. Der Induktor lag entweder im Mesenchym, oder aber er ging in einer Reihe von Fällen aus der Somatopleura ins Innere des Explantats, in der Richtung des Darms, über.

III. Schlusswort. Die Trans- und Explantationsversuche geben ein und dieselbe Antwort auf die in dieser Arbeit gestellte Frage: eine Induktion der Anfangsstadien einer Extremitätsbildung kann nur bei Vorhandensein des Seitenmaterials (Epithel und Mesoderm) und eines Induktors, bei Ausschliessung anderer Einwirkungen von Seiten der mit dem Seitengebiet zusammenhängenden Faktoren hervorgerufen werden. Beim angewandten Verfahren gelingt es die Extremitätsknospe in Gestalt einer linsenförmigen Anlage zu induzieren.

Die nächste Frage, die der Verfasser in einer anderen Arbeit erörtern wird, ist, ob die auf diesem Wege gewonnene Anlage sich zu einer typisch entwickelten Extremität ausbilden könne. Der Stoff der vorliegenden Arbeit kann uns keine Antwort auf diese Frage geben. Wenn auch in mehreren Fällen der Versuch lange genug (21 Tage) gedauert hat und die heterotopisch (auf den Kopf) induzierten Extremitätsanlagen in einer Reihe von Fällen augenscheinlich einen Involutionsprozess (die sich zerstreuenden Anlagen) durchgemacht haben, so wäre es doch vorzeitig anzunehmen, dass diese Anlagen unfähig seien eine Extremität ohne Beihilfe eines präsumptiven spezifischen, mit dem Seitengebiet des Keimkörpers in Verbindung stehenden Faktors zu bilden.

IV. Schlussfolgerungen. 1. Das Material des Seitengebietes eines Tritonenkeims kann keine Extremitätsanlage bilden, wenn es ohne Induktor (Nasenplakode) auf den Kopf eines anderen Keims verpflanzt wird. Wenn es mit dem Induktor zusammen verpflanzt wird, induziert sich die Extremitätsanlage.

2. Derart induzierte Extremitätsanlagen erreichen das Stadium einer grossen, gewölbten linsenförmigen Anlage. Ihre weitere Entwicklung ist nicht erzielt worden. In einer ganzen Reihe von Versuchen haben sie, augenscheinlich, einen Involutionsprozess durchgemacht.

3. Die Induktion der linsenförmigen Extremitätsanlage kann durch Explantation des Bauch- und Seitenmaterials des Keims nebst dem Induktor (Nasenplakode) erzielt werden.

4. Für die Entwicklung der Anfangsstadien der induzierten Anlagen sind folgende Teile durchaus notwendig: Material aus dem Seitengebiet (Epithel und Mesoderm) und ein Induktor. Andere spezifische Faktoren (Teile) können ausbleiben.

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